Agriculture Information Bulletin No. 311

Selection and use of WOOD PRODUCTS for HOME AND FARM BUILDING

UNITED STATES DEPARTMENT OF AGRICULTURE • Forest Service

Contents

Many Wood Products Now Available

Today it is more important than ever to select the most appropriate wood product for each use in residential and farm construction. Wood products are now being made in more forms and from a greater variety of species than ever before. What was most suitable for a particular use a few years ago may not be so today.

About 25 billion board feet of wood products are used each year by the construction industry in the United States—much of this for homes and farm buildings (fig. 1). In addition, more than 6 billion board feet of lumber are used annually to maintain, repair, and remodel structures.

The wood-based panel products[1] industry produces another 28 billion square feet of material in various thicknesses. Most of this material is used in new construction or remodeling.

This publication is intended for people who want a reliable source of information for judging and choosing wood products for various purposes. It presents in brief the essential requirements for the usual wood-frame building purposes, and shows how various woods and wood-based products meet these specific requirements. It also emphasizes some basic principles —often overlooked—that should be followed in good construction.

[1] Includes wood, particleboard, hardboard, and structural insulating board.

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FIGURE 1.—Wood serves in many parts of today's home, both on the farm and in suburban areas. Its adaptability to varied architectural treatment, as well as its service as a building material, is demonstrated throughout the Nation.

Good performance of a wood-frame structure will depend on good construction practices. Detailed information on construction practices is offered in Agriculture Handbook No. 73, "Wood-Frame House Construction," for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.25.

Natural color photographs and short descriptions of the wood and uses of 32 species of native trees (18 hardwoods and 14 softwoods) most commonly found in retail lumber markets are presented in Agriculture Handbook No. 101, "Wood: Colors and Kinds," available from the Superintendent of Documents for 75 cents. Please include your postoffice ZIP Code when ordering government publications.

Further information about wood and wood products for building purposes may be obtained from various trade associations.

While lumber is widely used in frame construction, sheet materials are also important. Wood-based panel materials are now broadly of three types—plywood, building fiberboard, and particleboard.

Plywood is a glued panel made up of layers of veneer (thin sheets of wood) with the grain of adjacent layers at right angles to each other. The kind of glue used determines whether it is Interior or Exterior type. Plywoods are classified by kinds and by qualities of faces. Those with hardwood faces are usually classed as *decorative* and those with softwood faces as *construction*. Exceptions for softwood plywood include, for example, face veneers of knotty pine or clear, cabinet grades, which are decorative. Plywood is graded on both front and back faces, in that sequence. (For example, A-C, B-B, C-D.)

Building fiberboards are produced with fibers interfelted so the board has some natural bonding. Additives improve the bond and impart strength. Boards of this type are generally classified by density into *structural insulating boards* (with a density of between 10 and about 31 pounds per cubic foot), *medium hardboards* (with a density of between about 31 and 50 pounds per cubic foot), and *high density* or *regular hardboard* (with a density of over 50 pounds per cubic foot).

Particleboards are produced by gluing small particles of wood together into a panel. Hot-setting resins produce the bond necessary to give the panels form, stiffness, and strength. They are generally classified as low density when the board has a density of less than 37 pounds per cubic foot, medium density when the density is between 37 and 50 pounds per cubic foot, and high density when the board weighs more than 50 pounds per cubic foot.

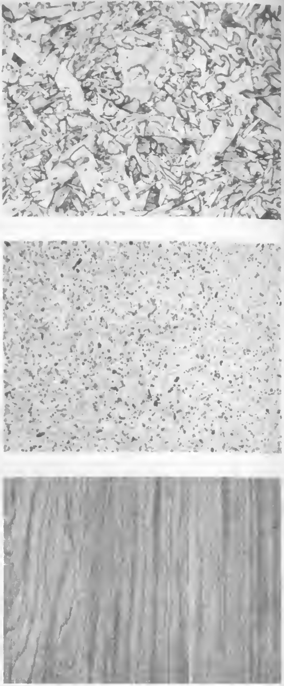

FIGURE 2.—Examples of particleboards. *Top:* Particleboard surface showing large decorative flakes representative of products commonly used for interior paneling. *Center:* Particleboard with fine surface particles (a small percentage of bark included), commonly used as core stock for overlaying with veneers or other decorative materials, as in *bottom* photo. (About one-half actual size). *(Forest Service photos)*

Classification Of Woods For Principal Home And Farm Uses

To select lumber and other wood-based material wisely, one must first single out the key requirements of the job. Then it is relatively easy to check the properties[2] of the different woods to see which ones meet these requirements.

A builder or property owner may believe that he needs a strong wood for the siding of his house or barn when he really requires a wood that takes paint well, is resistant to weathering, and develops little or no warping. Or he may think he needs a wood with high bending strength for the joists of his house, whereas adequate stiffness is more important. Other considerations include the moisture content of the wood, its ability to resist distortion (warping), and its shrinkage characteristics.

In buying sheathing material, one should consider not only the original cost but cost of application as well. Such factors as relative nail-holding qualities, insulation values, and the possible elimination of corner bracing should also be considered.

It is not necessary to purchase only the best quality lumber or wood-based products. Lower and cheaper grades serve satisfactorily for many uses.

The number of uses and the service requirements of wood vary so greatly that it is practically impossible to classify woods precisely according to their suitability for different uses solely on factual data. Such data, however, can be supplemented by the mature judgment of technical workers who have been impartially studying and testing the various woods for years, and have observed the performance of many woods under widely varying conditions. The opinion of such workers has been included, therefore, in classifying common U.S. wood species for principal home and farm uses.[3]

Wood species are divided into two classes—**hardwoods**, which have broad leaves, and **softwoods** or conifers, which have scalelike leaves or needles. The terms "hardwood" and "softwood" do not denote hardness or softness of the wood. In fact, some "hardwoods" like cottonwood and aspen are less dense (or hard) than some "softwoods" like southern pine and Douglas-fir.

The native species here listed are in general use and are classed conservatively for each specific purpose. Occasionally a species may be underrated for a particular use, or its range of suitability may be underestimated, but the ratings are on the side of safety from the general public's standpoint. (More data on wood properties and uses are contained in the "Wood Handbook," Agriculture Handbook No. 72.)

The following classification is simple and applies to average, typical conditions under which wood serves in a particular use. No attempt has been made to draw fine distinctions between woods. Neither is it to be inferred that all species of woods in the same class are equally suitable.

Grades vary considerably by species. Therefore, in this publication, a sequence of first, second, third, fourth, and fifth grade material is given for specific uses. In general, the first grade is for a high or special use, the second for better than average use, the third for average, and fourth and fifth for more economical, but still acceptable construction. (See discussion of grades starting on p. 25).

Suitability of Woods and Wood-based Products for Various uses

FOUNDATIONS—SILLS AND BEAMS (HOUSE)

Usual requirements: High stiffness and strength when used as a beam, good decay resistance, good resistance to withdrawal and lateral movement of nails. Good strength in compression perpendicular to grain (sills). Most woods are satisfactory as sills where dry conditions prevail, but for predominantly wet conditions, preservative-treated wood should be used.

Woods combining usual requirements in a *high* degree: White oak. (Fine for sills and beams in crawl spaces. Heartwood has high decay resistance but wood that is all heartwood usually costs more.)

Douglas-fir, western larch, southern yellow pine, and rock elm. High in strength and nail-holding qualities. (Sills and beams in basement or dry areas. Under moist conditions they require preservative treatment.)

Woods combining usual requirements in a *good* degree: Cedar and redwood. (Sills only, as these species do not have the high bending strength desirable for beams. Heartwood has high decay resistance.)

Poplar, eastern and west coast hemlock, red oak. (Require good preservative treatment if exposed to moist conditions or long periods of high humidity.)

Woods combining usual requirements in a *fair* degree: Ash, beech, birch, soft elm, maple,

[2] Distinguishing characteristics, qualities, or marks common to a species or group, usually classified as physical, mechanical, or chemical properties.

[3] A tabular summary of a detailed classification of woods by characteristics and properties appears on pp. 18 and 19.

and sycamore. (Good as beams and fair as sills, but require good preservative treatment if exposed to moist conditions.)

Northern white pine (eastern) and Idaho white pine (western), ponderosa pine, sugar pine, spruce, and white fir. (Satisfactory for sills but require good preservative treatment if exposed to moist conditions or high humidity.)

Grades used: Softwood sills that might be used in houses with crawl spaces are generally of second or third grade softwood Dimension material. For less exacting standards, but nonetheless satisfactory for secondary buildings, fourth grade material may be used. If lumber is not treated, all-heartwood pieces should be selected for sills near ground level and in moist areas where condensed moisture may be absorbed by sills. Hardwood sills are usually first grade Dimension in the best construction and second grade in ordinary construction.

FOUNDATIONS—PLATES AND SLEEPERS (HOUSE)

Usual requirements: Good natural decay resistance (or treated with preservative) under moist conditions, good nail-holding qualities, medium density. (Used as plates on concrete slab walls where top of wall is near finish grade, as sleepers on concrete slabs for fastening of finish flooring, and similar uses.)

Woods combining usual requirements in a *high* degree: White oak. (Heartwood has high decay resistance but costs more.)

Woods combining usual requirements to a *good* degree: Redwood, Douglas-fir, western larch, southern yellow pine, rock elm, and other medium-density species for normal conditions. Pressure-treated southern yellow pine, red oak, hemlock, and Douglas-fir for damp conditions.

Woods combining usual requirements to a *fair* degree: Northern and Idaho white pine, ponderosa pine, sugar pine, spruce, white fir, ash, beech, birch, maple, and sycamore for normal conditions.

Grades used: Third grade Dimension lumber of most softwood species under normal conditions.

FRAMING—JOISTS, RAFTERS, HEADERS (HOUSE)

Usual requirements: High stiffness, good bending strength, good nail-holding qualities, freedom from pronounced warp. For this use dryness and size are more important factors than inherent properties of the different woods. Allowable spans vary by species.

Woods combining usual requirements in a

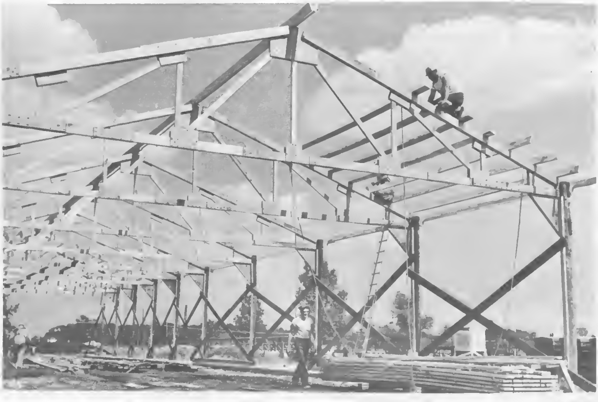

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FIGURE 3.—A variety of wood uses, and one way that different wood products may be combined, are illustrated in this experimental dry storage shed under construction. The pole and timber construction with clearspan roof trusses combines poles, plywood, boards, and dimension stock.

high degree: Douglas-fir, western larch, and southern yellow pine. (Extensively used.)

Ash, beech, birch, maple, and oak. (Seldom used as they are more difficult to obtain in straight pieces and harder to nail and saw than preceding group.)

Woods combining usual requirements in a *good* degree: Eastern and west coast hemlock, eastern and Sitka spruce, lodgepole pine, and white fir.

Northern and Idaho white pine, ponderosa pine, sugar pine, and redwood. (Seldom used because of adaptability to more exacting uses such as millwork, siding, and finish. Lower strength may be compensated for by using larger joists and rafters.) Poplar. (Seldom used.)

Woods combining usual requirements in a *fair* degree: Elm, gum, sycamore, magnolia, and tupelo. (Seldom used.)

Grades used: Second grade Dimension of most softwood species is used in first-class construction. Third grade is used in a large percentage of lower cost dwellings. The fourth grade is satisfactory for small buildings, but contains more crooked pieces than higher grades. Lumber used in trusses is often first grade and second grade, depending on the type of truss, span, species, and the type of member.

FRAMING—STUDS, PLATES (HOUSE)

Usual requirements: Moderate stiffness and nail-holding qualities, freedom from pronounced warp, and moderately easy workability (easy to saw and nail).

Woods combining usual requirements in a *high* degree: Douglas-fir, western larch, and southern yellow pine. (Extensively used.)

Woods combining usual requirements in a *good* degree: Eastern and west coast hemlock, spruce, white fir, balsam fir, lodgepole pine, and aspen.

Northern and Idaho white pine, ponderosa pine, sugar pine, and redwood. (Seldom used because of adaptability to more exacting uses as finish.)

Woods combining usual requirements to a *fair* degree: Elm, gum, sycamore, and tupelo. (Seldom used.)

Grades used: Because high bending strength is of secondary importance for studs and plates, grades lower than those commonly used for joists and rafters are satisfactory. Third grade softwood Dimension lumber is satisfactory for most dwellings built to good construction standards. Hardwoods in first and second grade Dimension are used in all types of construction.

SUBFLOORS (HOUSE)

Usual requirements:

Lumber.—Requirements are not exacting, but moderate stiffness, medium shrinkage and warp, and ease of working are desired.

Plywood.—Moderate stiffness when finish is strip flooring; high stiffness for wood block or resilient finish flooring. Good nail-holding qualities.

Softwood plywoods for use as subfloors with or without underlayment are classified by density, hence stiffness and strength, into groups. For each grouping a limit for span and loading is established. This is shown on each piece of plywood by a number such as "32/16." The first number indicates maximum span when used as roof sheathing and the second number indicates maximum span when used as subfloor. Here "16" indicates that the maximum span for living area space is framing 16 inches on centers.

Woods combining usual requirements in a *high* degree:

Lumber.—Douglas-fir, western larch, and southern yellow pine. (Commonly used.)

Ash and oak. (Seldom used because of adaptability to more exacting uses.)

Plywood.—Group 1 and 2 softwoods such as: Douglas-fir, southern yellow pine, and western larch.

Woods combining usual requirements in a *good* degree:

Lumber.—Hemlock, ponderosa pine, spruce, lodgepole pine, aspen, balsam fir, and white fir. (Commonly used.)

Northern and Idaho white pine, sugar pine, and poplar. (Seldom used because of adaptability to more exacting uses.)

Beech, birch, elm, hackberry, maple, oak, and tupelo. (Not used extensively, harder to work. Maple, elm, and oak often available locally.)

Plywood.—Group 3 and 4 softwoods such as: Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir.

Grades and types used (minimum recommended):

Lumber.—Third grade softwood boards are used extensively in better quality houses. In lower cost houses, both third and fourth grades are used. The fourth grade is serviceable and does not entail much waste, but is not as tight as the higher grades. When hardwoods are used, second grade boards are commonly used in the more expensive houses and third grade in the lower cost houses.

Plywood.—Standard interior grade (C-D) under ordinary conditions; in baths, kitchens, or when exposed to weather use Standard grade with exterior glue.

WALL SHEATHING (HOUSE)

Usual requirements:

Lumber.—Easy working, easy nailing, and moderate shrinkage.

Plywood. — Good nail-holding qualities, workability, and resistance to racking.

Structural insulating board and hardboard. —Good resistance to water, to nailhead pull-through, and to racking if properly attached.

Materials combining usual requirements in a high degree:

Lumber.—Cedar, hemlock, northern and Idaho white pine, ponderosa pine, sugar pine, redwood, aspen, spruce, balsam and white fir, basswood, lodgepole pine, and poplar. (Good racking resistance when applied at 45°, but not adequate when applied horizontally without bracing.)

Plywood.—Douglas-fir, southern pine, and western larch.

Structural insulating board and hardboards. —When applied vertically in 4- by 8-foot or longer sheets with perimeter nailing.

Materials combining usual requirements in a good degree:

Lumber.—Douglas-fir, western larch, and southern yellow pine. (Not as workable as previous lumber group.)

Plywood.—Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir.

Structural insulating board. — Regular-density structural insulating board (about 18 pounds per cubic foot in density) is furnished in 2- or 4-foot widths and, when applied with long edges horizontal, do not provide necessary resistance to racking forces of wind or earthquake so other bracing must be provided.

The more prevalent way to install insulating board sheathing is in 4-foot widths with long edges vertical. With proper fastening around the perimeter and along interior framing, adequate resistance to racking is provided. Manufacturers' recommendations should be followed for fastening.

Hardboards.—Hardboards are not generally used as wall sheathing but may be used as combined siding-sheathing (see section of "Combined Siding-Sheathing.")

Grades and types used:

Lumber.—Most woods are satisfactory for sheathing, though some woods are less time consuming to work than others. The third grade of Common softwood boards makes a serviceable sheathing when covered with a good building paper. First and second grades provide a tighter coverage but still require coverage with building paper. Fourth and fifth grades may be used as sheathing in low-cost houses, but are not generally available. Both entail some loss in cutting. When a hardwood is used for sheathing, second grade boards are adaptable to more expensive houses, and third grade to the lower cost houses.

Plywood.—Most species of plywood can be used with satisfactory results. For exterior finish such as shingles or shakes, thickness of softer plywoods should be increased to obtain greater nail penetration. Use Standard interior (C-D) under ordinary conditions; use Standard interior with exterior glue if house is in an unusually damp location.

Structural insulating board.—Structural insulating board is furnished in three grades—regular density, intermediate density, and nail-base. Regular density is manufactured in both the ½ and 25/32 inch thicknesses but the other two grades are only made ½ inch thick.

Intermediate density sheathing is somewhat more dense, hence stronger and stiffer, than regular density. Furnished only in 4- by 8-, or 4- by 9-foot sizes. When properly applied with long edges vertical it satisfies racking requirements while the ½-inch-thick regular density board usually does not. Nail-base sheathing is more dense than intermediate-density and in addition to providing racking resistance has sufficient nail-holding strength to hold some kinds of siding on the wall when special nails are used. Insulating board sheathing must be attached to framing with large-headed (roofing) nails or special staples. These fasteners should have a corrosion-resistant coating.

ROOF SHEATHING (HOUSE)

Usual requirements:

Lumber.—Moderate stiffness, good nail holding, little tendency to warp, ease of working.

Plywood.—Adequate stiffness for span and roof loading. Sheathing grade plywoods are classified into groups by density, hence strength and stiffness. Each grouping sets the distance between supports for proper application and performance. Each sheet is marked with a number such as "32/16" as previously listed under "Subfloors."

Woods combining usual requirements in a *high* degree:

Lumber.—Douglas-fir, western larch, and southern yellow pine. (Commonly used.)

Ash, beech, birch, elm, hackberry, maple, oak, and tupelo. (Not extensively used; harder to work.)

Plywood.—Group 1 and 2 softwoods such as: Douglas-fir, southern yellow pine, and western larch.

Woods combining usual requirements in a *good* degree:

Lumber.—Hemlock, ponderosa pine, spruce, lodgepole pine, aspen, and white and balsam fir. (Commonly used.)

Northern and Idaho white pine, sugar pine, redwood, and poplar. (Seldom used because of adaptability to more exacting uses.)

Plywood.—Group 3 and 4 softwoods such as: Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir.

Grades and types used:

Lumber.—Third grade Common softwood boards are used extensively in better quality houses. In lower cost houses, both third and fourth grades are used. Fourth grade is serviceable but not as tight as third grade. When hardwoods are used, second grade boards can be used in high-quality houses and third grade in lower cost houses.

Plywood.—Use Standard interior grade (C-D) under ordinary conditions; for unusually damp conditions use Standard interior grade with exterior glue.

PLANK ROOF DECKING (HOUSE)

Usual requirements: Moderate stiffness and strength, moderate stability, moderate insulating value. (For short to moderate spans of 2 to approximately 16 feet in length, flat and low-pitch roofs.)

Materials combining usual requirements in a *high* degree: Solid or laminated wood decking (edge matched) of southern yellow pine, Douglas-fir, or other softwood (1⅝ to 3⅝ inches thick).

Materials combining usual requirements in a *good* degree: Structural insulating roof deck.

Grades and types used.

Wood decking.—With solid wood for high-quality houses, first grade; slightly lower class, second grade; standard use (houses and garages), third grade. With laminated wood for high-quality houses, first grade (Select or decorative one face); lower cost houses and other buildings, second grade (Service type).

Structural insulating roof deck.—Specially fabricated products. Types vary by: (a) thicknesses (1½, 2, and 3 inches depending on span and insulation requirements), (b) surface treatment, and (c) vapor barrier needs.

SHINGLES, SHAKES (HOUSE)

Usual requirements: High decay resistance, little tendency to curl or check, freedom from splitting in nailing. (Roof and sidewalls.)

Woods combining usual requirements in a *high* degree: Cedar, cypress, and redwood. (Principal shingle woods; heartwood only, edge grain.)

Woods combining usual requirements to a *good* degree: Northern and Idaho white pine, ponderosa pine, and sugar pine. (Handmade shingles or shakes from locally grown timber; for best utility require good preservative treatment.)

White oak. (Handmade shingles or shakes from locally grown timber; require care in nailing.)

Grades used:

Roofs.—In western red cedar, cypress, and redwood, first grade shingles (all-heart, edge-grained clear stock) should be used for the longest life and greatest ultimate economy. Other all-heart but not edge-grained grades, such as second grade in redwood, western red cedar, and cypress, are frequently used to reduce initial cost and for low-cost houses and secondary buildings.

Sidewalls.—Same species as used for roofs. For best construction on single-course sidewalls use first grade (all-heart, edge-grained clear). For double-course sidewalls use third grade for undercourse, and first grade for outer course for best construction, and use second grade outer course to reduce costs.

EXTERIOR TRIM (HOUSE)

Usual requirements: Medium decay resistance, good painting and weathering characteristics, easy working qualities, and maximum freedom from warp.

Woods combining usual requirements in a *high* degree: Cedar, cypress, and redwood. (Heartwood has natural decay resistance, edge grain preferable for best paint-holding qualities. Most adaptable to natural finishes and stains.)

Northern and Idaho white pine, ponderosa pine, and sugar pine. (Adaptable to ordinary trim.)

Woods combining usual requirements in *good* degree: West coast hemlock, ponderosa pine, spruce, poplar, Douglas-fir, western larch, and southern yellow pine. (Edge-grained boards and special priming treatment advisable to improve paint-holding qualities.)

Grades used: First grades (A, B, or B and Better Finish) are used in the best construction. Second grades (C and D Finish) are used in more economical construction, and first or second grade Common boards where appearance is not important. Clear finger-joint boards are often used when trim is to be painted.

FRAMES AND SASH (HOUSE)

Usual requirements: Good to high decay resistance, good paint holding, moderate shrinkage, freedom from warping, good nail holding, and ease of working.

Woods combining usual requirements in a *high* degree: Cypress, cedar, and redwood. Northern and Idaho white pine, ponderosa pine, and sugar pine. (Principal woods used for sash and window and outside doorframes. Usual preservative treatment consists of 3-minute dip in water-repellent preservative.)

Woods combining usual requirements in a *good* degree: Douglas-fir, western larch, and southern yellow pine. (Require dip treatment.)

White oak. (Harder to work and higher shrinkage than softwoods. Usually used for outside doorsills and thresholds.)

Grades used: Grades of lumber for sash and frames are Shop grades and are of primary interest to manufacturers rather than users. The majority of door and window frames and sash are treated with water-repellent preservative at time of manufacture. Decay-resistant species should be considered for basement frames and sash where resistance to moisture and decay is more important. Under severe moisture conditions pressure-treated material is desirable.

SIDING (HOUSE)

Usual requirements: Good painting characteristics, medium decay resistance, easy working qualities, and freedom from warp. (For lap siding, drop siding, matched vertical boards, vertical boards and battens, etc.)

Lumber siding.—Woods combining usual requirements in a *high* degree: Western red cedar, cypress, and redwood. (Extensively used. Heartwood preferable; edge-grained siding has best paint-holding qualities. Most adaptable of species to natural finishes and stains.)

Woods combining usual requirements in a *good* degree: Northern and Idaho white pine, sugar pine, and white cedar. (Heartwood has medium decay resistance.)

West coast hemlock, ponderosa pine, spruce, and poplar. (Edge grain for best paint retention in such species as hemlock.)

Woods combining usual requirements in a *fair* degree: Douglas-fir, western larch, and southern yellow pine. (Edge grain only.)

Grades used: Redwood and cypress first siding grades (Clear Heart) and western red cedar in a first grade (Clear) for best quality construction. In other softwoods the first grade (B and Better) siding is used in best quality houses. Siding in more economical types of construction is usually of second grade (C or D), but third grade (No. 1 and No. 2) is available in a number of species. Rough-sawn siding patterns in the lower grades are suitable for stain finishes.

Other siding materials.—Paper-overlaid plywood or lumber (resin impregnated in the paper overlay) in sheet form or in manufactured forms for board and batten effect, and in patterns for horizontal siding. Rough-textured plywoods in various patterns and exterior grades are suitable for stain finishes.

Medium hardboard in densities of 32 to 50 pounds per cubic foot. In sheet form or in manufactured widths for horizontal siding. May be plastic coated or factory primed ready for finish paint coats.

High-density or regular hardboards in densities of 50 to 70 pounds per cubic foot. In panel form only. Four- by 8-foot or longer applied with long edges vertical. Such hardboards are not usually recommended for use as lapped (clapboard) siding.

Combined sheathing-siding.—Wood-base panel products can provide both the function of sheathing and siding when applied in large sheets to provide racking resistance and reduction of air infiltration. Special plywoods like rough-sawn western redcedar and "Texture 111" with exterior gluelines are manufactured for this use.

Medium-density hardboards and to a limited extent high-density hardboards are also manufactured for this use. They may have a plain or embossed surface. Plywood and hardboard may be grooved to create reversed board and batten effects, or may have a plain surface and be applied with battens to create the board and batten effect.

Plywood is usually stained; hardboard may be painted or stained.

DECKING AND OUTDOOR STEPPING (HOUSE)

Usual requirements: High decay resistance, nonsplintering, good stiffness, strength, wear resistance, and freedom from warping. (If painted, should have good paint retention.)

Woods combining usual requirements in a *high* degree: White oak. (Edge grain.)

Locust and walnut. (Usually unavailable except when cut from locally grown timber.)

Woods combining usual requirements in a *good* degree: Douglas-fir, western larch, redwood, cedar, and southern yellow pine. (Edge grain only, heartwood preferred.) For moderate life, Douglas-fir and southern yellow pine require preservative treatment. (Softer woods not as wear resistant.)

Grades used: Second (C Finish) or a higher grade in softwoods and first and second Finish grades in hardwoods are used in high-quality construction. In lower cost construction, first grade Dimension in hardwoods and as low as second grade Dimension in softwoods are used. First and second grades in softwoods are serviceable but wear unevenly around knots.

INTERIOR TRIM WITH NATURAL FINISH (HOUSE)

Usual requirements: Hardness, freedom from warp, pleasing texture and grain.

Woods combining usual requirements in a *high* degree: Oak, birch, maple, cherry, beech, sycamore, and walnut. Cypress (pecky) and

maple (curly or bird's eye). *Knotty surface.*—Cedar, ponderosa pine, spruce, sugar pine, gum, and lodgepole pine.

Woods combining usual requirements in a *good* degree: Douglas-fir, west coast hemlock, western larch, southern yellow pine, redwood, aspen, and magnolia. (With conventional architectural treatment.)

Grades used: High-class hardwood interior trim is usually first grade Finish (A grade). The softwood Finish Grade A or B and Better is commonly used in high-quality construction. In the more economical types of construction, C grade is serviceable. D grade requires special selection or some cutting to obtain clear material. Special grades of knotty pine, pecky cypress, and others are available to meet special architectural requirements in some types of high quality construction.

INTERIOR TRIM WITH PAINT FINISH (HOUSE)

Usual requirements: Fine and uniform texture, moderate hardness, absence of knots and discoloring pitch, good paint holding, and freedom from warp and shrinkage.

Woods combining usual requirements in a *high* degree: Northern and Idaho white pine, ponderosa pine, sugar pine, and poplar. (Where likelihood of marring is negligible.)

Woods combining usual requirements in a *good* degree: Hemlock, redwood, spruce, white fir, magnolia, basswood, beech, gum, maple, and tupelo.

Douglas-fir, western larch, and southern yellow pine. (Edge grain most satisfactory.)

Grades used: C Finish is the lowest softwood grade commonly used for high-quality paint and enamel finish. D Finish can be used but requires some selection or cutting. First grade Common is used for ordinary or rough-paint finishes. In more economical homes second grade Common may be used for ordinary or rough-paint finishes. Smooth-paint finishes are difficult to obtain and maintain over knots in first, second, and third grade Common softwoods.

First grade Finish in the hardwoods is used for exacting requirements of high-quality paint and enamel finish in more expensive homes. The second grade Finish in hardwoods is also used but requires some selection or cutting. Second grade boards in hardwoods may be used for interior trim in the low-cost home, but for interior trim that is to be painted softwoods are generally used.

UNDERLAYMENT FOR FINISH FLOORS

Ordinarily all finish flooring except standard strip flooring and ½- or ¾-inch wood block floor are laid with an underlayment between the subfloor and the finish flooring. This is especially necessary for resilient floor surfacing (rubber, vinyl, vinyl asbestos, or asphalt in tile or sheet form) because of its thinness, flexibility, and tendency to "showthrough" the pattern of the surface beneath it.

Floor underlayment serves the following functions:

1. Provides uniform support for finish flooring.
2. Bridges small irregularities in the subsurface.
3. Because joints in floor underlayment do not coincide with those in subfloor, there is less chance for working of joints to loosen or break finish flooring.
4. Provides a smooth, uncontaminated surface for gluing to the base those kinds of finish flooring requiring it.
5. Permits vertical adjustment in floor levels so all rooms are at the same elevation even when different floorings are used. The subfloor usually serves as the working platform. During the period between initial laying of subfloor and installation of finish flooring the surface may be roughened from wetting, dented from impacts, or contaminated with plaster, dirt, grease, and paint, in fact anything that is tracked or brought into the building.

Some use of combined subfloor-underlayment is developing, particularly in factory-built or tract-built housing where subfloors are given special protection during construction or where pad and carpet are installed.

Floor underlayments are plywood, hardboard, or particleboard.

Plywood underlayment.—Plywood underlayment is a special grade produced for this purpose from group 1 woods (for indentation resistance). It is produced in ¼-, ⅜-, ½-, ⅝-, and ¾-inch thickness, and the face ply is C plugged grade (no voids) with a special C or Better veneer underlying the face ply to prevent penetration from such concentrated loads as high heels.

Particleboard underlayment.—Produced in the same thicknesses as plywood, particleboard underlayment is often preferred because its uniform surface and somewhat higher density make it more resistant to indentation than plywood when thin resilient flooring is applied over it. Because it tends to change more in length and width with changes in moisture content than plywood, manufacturers' directions for installation and specifications for adhesives must be followed for good performance.

Hardboard underlayment.—Produced in 4-foot squares, 0.220 inch thick and planed to uniform thickness, hardboard underlayment should be installed to manufacturers' specifications for proper performance. It is mainly used on remodeling or in new construction where minimum thickness buildup is desired.

FLOORING—STRIP AND WOOD BLOCK (HOUSE)

Usual requirements: High resistance to wear, attractive figure or color, minimum warp and shrinkage. (Material should be used at a moisture content near the level it will average in service.)

Woods combining usual requirements in a *high* degree: Maple, red and white oak, beech, and birch. (Most commonly used hardwoods.)

White ash and walnut. (Not commonly used.)

Hickory and pecan. (Not commonly available. Harder to work and nail. More suitable to woodblock flooring.)

Woods combining usual requirements in a *good* degree: Cherry, gum, and sycamore (edge grain). (Not commonly available. Highly decorative and suitable where wear is not severe.)

Cypress, Douglas-fir, west coast hemlock western larch, and southern yellow pine (edge grain). (More suitable in low-cost houses in bedrooms where traffic is light.)

Grades used: In beech, birch, and maple flooring the grade of Firsts is ordinarily used for better quality homes, and Seconds and sometimes Thirds in economy houses. In oak, the grade of Clear (either flat or edge grain) is used in better construction, and Selects and sometimes No. 1 Common in lower cost work or where small tight knots provide the desired effect. Other hardwoods are ordinarily used in the same grades as oak.

When softwood flooring is used (without covering) in better quality homes, grade A or B and Better edge grain is used. Grade D or C (edge grain) is used in low-cost homes.

The three general types of material used for finish floors are wood strip, wood block, and resilient flooring such as rubber, vinyl, or asphalt tile, or linoleum.

Strip flooring.—Is usually laid over boards nominally 1 inch thick because the boards must be thick enough to hold the nail. For best results, boards for subfloors are laid diagonally and in nominal widths no greater than 6 or 8 inches. Plywood ⅝ or ¾ inch thick is also satisfactory. One-half inch plywood is satisfactory for subfloor when strip flooring is nailed to floor joists.

Wood block flooring.—Because wood block flooring requires an even and uniform base for best results, plywood subfloor is frequently used. A ⅝- or ¾-inch thickness should be used if block flooring is installed by nailing. Laminated block flooring ½ inch thick or less may be used over a ¼- or ⅜-inch plywood or particleboard underlayment that has been nailed to a wood subfloor.

Resilient flooring.—Because resilient floors are usually quite thin and are installed with adhesives, it is necessary to provide a smooth base. Plywood, particleboard, or hardboard—all of a special underlayment grade—are most frequently used over various types of subfloors. Underlayment screws are commonly used to fasten the underlayment and minimize "popups" that can occur with other fastenings.

MISCELLANEOUS MILLWORK (HOUSE)

Interior millwork usually varies a great deal between houses, both in the type and amount used. Uses in the average homes include doors, kitchen cabinets, shelving, and stairs. Other homes may, in addition, involve the use of such millwork items as fireplace mantels, wall paneling, ceiling beams, china closets, bookcases, and wardrobes.

Doors

Usual requirements: Freedom from warp (especially for outside doors), good finishing qualities, resistance to denting (hardness), pleasing figure or grain for natural finish or good base for paint.

Other attributes and sometimes requirements of doors include resistance to fire and sound transmission, ability to hold special hardware, means to accept cutouts or openings for windows, and durability. Doors use either an interior or exterior quality glue for assembly, depending on where they are to be used.

Door manufacture is of two types—the panel door with insert panel and solid or veneered stiles and rails, and the flush door with skins bonded to frames. The flush door is manufactured in hollow core construction (for interior doors) and solid core (for exterior doors in cold and moderate climates).

Woods combining usual requirements in a *high* degree: Oak and birch. (Natural finish.)

Woods combining usual requirements in a *good* degree: Ponderosa pine, Douglas-fir, southern yellow pine, and spruce. Gum for natural finish or painting.

Stairways

Usual requirements for treads, risers, and stair parts: Hardness and wear resistance (treads, railings), freedom from warp, pleasing grain.

Woods combining usual requirements in a *high* degree: Oak, birch, maple, walnut, beech, ash, and cherry (exposed treads and risers.)

Woods combining usual requirements in a *good* degree: Douglas-fir, southern yellow pine, gum, and sycamore (basement or secondary stairs or when stairs are to be carpeted).

Cabinet Doors

Usual requirements: Pleasing grain, freedom from warp, moderate hardness.

Woods combining usual requirements in a *high* degree: Maple, oak, birch, and cherry. (Suitable for natural finishes and for plywood flush doors.)

Woods combining usual requirements in a

good degree: Douglas-fir, southern yellow pine, gum, ponderosa pine, magnolia, and poplar for paint finish.

Shelving

Usual requirements: Stiffness, freedom from warp.

Woods combining usual requirements in a *high* degree: Ash, birch, maple, oak, and walnut. (Suitable for natural finishes.)

Douglas-fir, poplar, southern yellow pine, redwood, ponderosa pine, sugar pine, and Idaho white pine. (Suitable for paint finish.)

Woods combining usual requirements in a *good* degree:

Lumber.—Hemlock, spruce, and western larch.

Plywood.—Natural finish: Oak and birch. (Most available species.) Painted finish: Douglas-fir, southern yellow pine, and other softwoods.

Particleboard.—Though only one-fourth to one-eighth as stiff as wood or plywood, particleboard is being used increasingly where loading is light, extra support is provided, or where spans are short. Frequently veneered or overlaid with higher stiffness materials to provide additional stiffness.

PANELING (HOUSE)

Usual requirements (for natural finish or light staining): Pleasing grain, figure or surface treatment, freedom from warp and shrinkage and some resistance to abrasion.

Woods combining usual requirements in a *high* degree:

Lumber.—Oak, redwood, cypress (pecky), walnut, cedar (knotty), ash, birch, pine (knotty), and cherry.

Plywood.—Oak, birch, maple, pecan-hickory, and walnut.

Woods combining usual requirements in a *good* degree:

Lumber.—Gum, western larch, Douglas-fir, beech, southern yellow pine, hemlock, and ponderosa pine.

Plywood.—Cedar, pine, Douglas-fir, southern yellow pine, and some imported species. (Some are specially treated to create a variation in the grain for unique surface effects.)

Grades and types used:

Lumber.—The best grade in hardwood for high quality houses is first grade. Softwood first or second grades are commonly used in the better house. Third grade is more economical. Special grades of knotty pine, peckv cypress, and sound wormy oak are sometimes available for special paneling treatment.

Plywood.—Unfinished: good or special surface one side, interior or exterior types. Prefinished: V-grooved and others (good one side or equal.)

Other materials.—Hardboards with special grain printing, embossing, or other surface treatments or decorative laminate overlays. Structural insulating board in sheet or plank form for walls and in tile form or lay-in panel for ceiling. (Factory treated, finished, or special acoustical effect.) Particleboards with veneered plastic, or other overlay face.

BARNS

Wood and wood-based materials for barns and similar buildings are generally the same as those outlined for houses. Grades are usually lower but in some uses strength is the most important factor, and the need for the additional strength is often reflected in the recommended grades and species. Lower grades can be used for siding, flooring, and trim than are ordinarily used for houses.

POLES

Usual requirements: (For load-bearing poles and posts used in such construction as pole barns, the butt end of the pole is usually embedded in the soil.) High stiffness and strength, freedom from crook, minimum taper, good nail holding, good decay resistance. (All poles used in permanent construction should be pressure treated in compliance with Federal Specification TT-W-571. This specification is available from the nearest General Services Administration Business Service Center for 10 cents.)

Woods combining usual requirements in a *high* degree: Western larch, Douglas-fir, west coast hemlock, and southern yellow pine. (Must be preservative treated.)

Woods combining usual requirements in a *good* degree: Lodgepole pine, jack pine, red pine, and ponderosa pine. (Must be preservative treated.)

Woods combining usual requirements in a *fair* degree: Western red cedar and northern white cedar. (Heartwood of cedars has good decay resistance.)

Classes used: The class of pole required in a building is usually determined by the circumference at the top. Classes vary from Class 1 poles with 27-inch minimum top circumference to Class 10 poles with 12-inch minimum top circumference. Poles should bear identification markings. Lengths vary and include distance above ground as well as embedment depth.

SILLS ON FOUNDATION WALLS (BARN)

Usual requirements: Good nail holding, moderate hardness, and good decay resistance (pressure treated in accordance with recognized standard such as Federal Specification TT-W-571 for permanent use). High stiffness and strength are important when piers or posts are used instead of walls, and the sill acts as a beam.

Woods combining usual requirements in a

high degree: Cedar, redwood, and white oak. (Heartwood has high decay resistance. Cedar and redwood have lower bending strength and are usually not used as beams.)

Woods combining usual requirements in a *good* degree: Douglas-fir, western larch, southern yellow pine, rock elm, and poplar. (High in strength and nail holding.)

Woods combining usual requirements in a *fair* degree: Eastern and west coast hemlock, northern and Idaho white pine, ponderosa pine, sugar pine, spruce, white fir, ash, beech, birch, soft elm, maple, red oak, and sycamore.

Grades used: Softwood sills in large barns are generally of second Dimension grade. Third grade is used in small and low-cost barns. Second and third Dimension grades usually have a high percentage of heartwood. Unless material is pressure treated, all-heartwood pieces should be selected for sills, especially where foundation walls are close to the ground. Hardwood sills are usually of the first Dimension grade in large barns and of the second grade in small barns.

STUDS, PLATES (BARN)

Usual requirements: Medium stiffness and strength, good nail holding, medium freedom from warp, moderate ease of working. In some barns, especially dairy, preservative treatment or good natural decay resistance is an added requirement. Studs in cribs or granaries are subjected to heavy lateral pressures from stored grain and require strength and stiffness in addition to good fastenings.

Woods combining usual requirements in a *high* degree: Douglas-fir, western larch, and southern yellow pine.

Redwood. (Heartwood decay resistance is high, but has lower bending strength.)

Woods combining usual requirements in a *good* degree: Hemlock, northern and Idaho white pine, ponderosa pine, sugar pine, lodgepole pine, Sitka spruce, white fir, eastern spruce, balsam fir, aspen, and poplar.

Ash, beech, birch, locust, maple, and oak. (Harder to nail and fabricate.)

Elm, gum, hackberry, and sycamore. (More difficult to fabricate and not widely available.)

Grades used: Third Dimension grade is the principal softwood grade used for studs in normal construction, but second grade should be used for cribs and granaries. Fourth grade is serviceable but is more difficult to fabricate because it contains more crooked pieces and entails some loss in cutting. Fourth grade is used in small, inexpensive barns. Hardwoods in second grade Dimension are used in most types of construction.

JOISTS, RAFTERS (BARN)

Usual requirements: High stiffness and strength, good nail holding, and moderate ease of working. Woods of moderate bending strength can be used with satisfactory results if lower strength is compensated for by the use of larger members, by closer spacing, or by shorter spans.

Woods combining usual requirements in a *high* degree: Douglas-fir, western larch, and southern yellow pine.

Ash, beech, birch, maple, and oak. (Harder to nail and work, not widely available.)

Woods combining usual requirements in a *good* degree: Hemlock, redwood, Sitka spruce, white spruce, white fir, elm, gum, hackberry, sycamore, tupelo, and poplar.

Woods combining usual requirements in a *fair* degree: Cedar, northern and Idaho white pine, ponderosa pine, sugar pine. Engelmann spruce, aspen, basswood, and cottonwood.

Grades used: The third Dimension grade of most softwood species is used in normal construction. Added strength in large, high-class barns can be obtained by the use of second grade Dimension. For long spans, stress grades might also be considered to eliminate larger sizes or closer spacing of members. The fourth grade of all softwood species is used in small and low-cost barns. The hardwood grades used are second grade for most farm buildings.

ROOF SHEATHING (BARN)

Usual requirements:

Lumber.—Medium stiffness, good nail holding, low shrinkage, medium decay resistance, freedom from splitting.

Plywood.—Good stiffness, good nail holding, resistance to delamination in high humidities.

Woods combining usual requirements in a *high* degree:

Lumber.—Douglas-fir, western larch, and southern yellow pine.

Plywood.—Group 1 and 2 such as: Douglas-fir and southern yellow pine. (Most available.)

Woods combining usual requirements in a *good* degree:

Lumber.—Hemlock, aspen, lodgepole pine, northern and Idaho white pine, ponderosa pine, sugar pine, spruce, white fir, and redwood. (Render good service in barns with low decay hazard.)

Elm, gum, oak, poplar, beech, birch, and maple. (Sometimes available from locally grown timber.)

Plywood.—Group 3 and 4 such as: Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir.

Grades and types used:

Lumber.—The third Common board grade is normally used in construction of most barns. The fourth grade is serviceable and may be used in small low-cost barns but

usually entails some waste in cutting.

Plywood.—Use Standard interior grade (C-D) for dry conditions and Standard interior grade with exterior glue for damp conditions.

SIDING AND BARN BOARDS (BARN)

Usual requirements:

Lumber.—Good painting or weathering qualities, freedom from warping or splitting, medium decay resistance. Medium bending strength when used without sheathing backing or with only a nominal number of cross supports. Boards subjected to dampness from the ground or to constant wetting should have high decay resistance or have a preservative treatment.

Plywood.—Good finishing or weathering qualities, freedom from warping and delamination, medium decay resistance. Medium bending strength in walls with wide spacing of frame members and without interior lining.

Woods combining usual requirements in a *high* degree: Cypress, cedar, and redwood. (Heartwood.)

Woods combining usual requirements in a *good* degree:

Lumber.—Northern and Idaho white pine, ponderosa pine, sugar pine, and poplar. (Heartwood preferable.)

Douglas-fir, western larch, and southern yellow pine. (Edge grain preferable. Should be given special priming coats and protected against weathering by good paint maintenance.)

Plywood.—Group 1 and 2 such as: Douglas-fir and southern yellow pine. (Most available.)

Woods combining usual requirements in a *fair* degree:

Lumber.—Hemlock, spruce, aspen, lodgepole pine, balsam fir, and white fir.

Plywood.—Group 3 and 4 such as: Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, and white fir. (Also have good paint retention.)

Grades and types used.

Lumber.—The grade of bevel siding is generally higher than the grade used with drop siding or barn boards. When bevel siding is used, it is usually in third and fourth grade, depending on species. When drop siding is used, it is usually second and third grade in the better quality barns. However, the lowest grades are generally serviceable in the lower cost barns. Fourth grade Common boards are also used extensively in lower cost barns. Second grade Common boards are used in the higher quality but entail some loss.

Plywood.—If the building is to be painted, overlaid plywood is used for highest quality buildings. For stained finishes use C-C Exterior (unsanded) grade. Exterior plywood with various surface treatments would also be satisfactory for buildings that are to be stained.

FEED RACKS AND FEED BUNKS

Usual requirements: Hardness, nonsplintering. (Edge grain for most satisfactory outdoor use).

Woods combining usual requirements in a *high* degree: Ash, beech, birch, locust, rock elm, hickory, maple, oak, and soft elm.

Woods combining usual requirements in a *good* degree: Douglas-fir, western larch, southern yellow pine, redwood, gum, and tupelo.

Grades used: The hardwoods are used in first and second Dimension grades, the softwoods in second and third grades. In the more economical type of work, softwood grades as low as fourth grade prove satisfactory.

FENCE POSTS

Usual requirements: High decay resistance and little or no sapwood for untreated posts. Good bending strength, straightness, and high staple holding. Permanent installation requires a good preservative treatment. High sapwood content is desirable for fence posts to be preservative treated.

Woods combining usual requirements in a *high* degree: Black locust and osage orange. (Meet most requirements, but not readily available in all parts of the United States.)

White oak. (Heartwood only. Generally available in the Eastern States, but life shorter than preceding group if not treated.)

Cedar, cypress, and redwood. (Heartwood only. Readily available but do not hold smooth shank staples and nails so well as preceding groups.)

Woods combining usual requirements in a *good* degree: Douglas-fir, western larch, and southern yellow pine (preservative treatment required).

Woods combining usual requirements in a *fair* degree: Beech, birch, maple, red oak, and elm. (Equal the best woods when given a good preservative treatment.) Hemlock, spruce, white fir, basswood, cottonwood, gum, tupelo, poplar, and lodgepole pine.

Grades used: Fence posts have no standard grades, but are specified by top diameters and by lengths. Treated posts should be branded or stamped to identify the treatment and source.

GATES, FENCES

Usual requirements: Good bending strength, good decay and weather resistance, high nail holding, freedom from warp. Treatment desirable for severe conditions. (Should also be lightweight for gates.)

Woods combining usual requirements in a

high degree: Douglas-fir, western larch, southern yellow pine, redwood, and white oak.

Woods combining usual requirements in a *good* degree: Cedar, northern and Idaho white pine, ponderosa pine, sugar pine, and poplar. (Small tendency to warp, weather well, but are low in strength and nail holding. All except cedar have moderately low resistance to decay.)

Beech, birch, gum, maple, red oak, and tupelo. (Strong, high in nail holding, but have greater tendency to warp, do not weather so well as preceding group, and are too heavy for gates. All except gum and maple have moderately low resistance to decay.)

Eastern and west coast hemlock, white fir, and spruce. (Intermediate qualities except for decay resistance, which is moderately low.)

Grades used: Second and third grade softwood Common boards and second hardwood board grades are used in better and more substantial gates and fences. In smaller and more economical gates and fenees, third grade hardwood boards are used. A softwood grade as low as fourth grade Common boards may be used, but entails some loss because of cutting out the larger defects.

CONCRETE FORMS—FRAMING AND SHEATHING

Usual requirements:

Lumber framing and sheathing.—Good stiffness, good bending strength, resistance to warping and splitting during installation and reuse, ease of working, smooth surface.

Plywood sheathing.—Good stiffness, water resistance, good bending strength, resistance to warping.

Woods combining usual requirements in a *high* degree:

Lumber framing and sheathing.—Douglas-fir, western larch, and southern yellow pine—often with fiber overlays when forms are reused. (High strength, good reuse value.)

Plywood sheathing.—Douglas-fir, western larch, and southern yellow pine.

Woods combining usual requirements in a *good* degree:

Lumber framing and sheathing.—Northern and Idaho white pine, eastern and west coast hemlock, ponderosa pine, redwood. white fir, white spruce, and Sitka spruce. (Easy to cut and nail.)

Plywood sheathing.—Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir. (Almost any species of plywood is suitable for formwork with correct spacing of supports.)

Grades and types used:

Lumber.—With compensation in size of material or in frequency of bracing, almost all woods can be used in ordinary construction for concrete forms. Second and third Common board grades of softwoods in dressed and matched or shiplap form, and second board grade hardwoods are used for coverage in forms with minimum bracing. Fourth grade softwoods or third grade hardwoods are used for forms in which the spacing is close or the loads are small. Framing and bracing utilizes third or fourth grade Dimension in softwoods and second grade Dimension in hardwoods. Concrete forms lined with "formboard" hardboard permit the use of lower grade boards than if lumber alone is used.

Plywood.—"Plyform" with sanded faces and mill oiled is most commonly used.

SCAFFOLDING

Usual requirements: High bending strength, high stiffness, high nail holding, medium weight, and freedom from compression failures and crossgrain.

Woods combining usual requirements in a *high* degree: Douglas-fir, western larch, and southern yellow pine.

Woods combining usual requirements in a *good* degree: Redwood, spruce, and west coast hemlock. (Lower bending strength.)

Birch, white ash, elm, maple, and oak. (Harder to saw and nail.)

Woods combining usual requirements in a *fair* degree: Sugar pine, ponderosa pine, and Idaho white pine. (Low stiffness and strength.)

Grades used: First grade softwood Dimension is usually required for scaffolding that must support loads under conditions that involve hazards. Light scaffolding may be selected from second grade softwood Dimension; in hardwoods, uprights can be selected from first grade Dimension. Selection should eliminate all pieces with compression failures, large or unsound knots, and crossgrain.

Some State building codes designate the grades to be used for scaffolding. Southern pine and western grading rules include special scaffolding plank grades.

EXPOSED PLATFORMS AND PORCHES

Usual requirements: High decay resistance, good stiffness and strength for framing, and good wear and splinter resistance for decking. (Where wood is exposed to severe moisture conditions, treated material is recommended.)

Woods combining usual requirements in a *high* degree: Redwood, locust, and white oak. (Heartwood only.)

Woods combining usual requirements in a *good* degree: Cedar, Douglas-fir, western larch, southern yellow pine, and rock elm. (Edge grain.)

Grades used: First or second grade Dimension in softwoods and first grade Dimension in hardwoods are the grades ordinarily used.

TANKS, VATS, STORAGE BINS

Usual requirements: High decay resistance

and low shrinkage. Treated wood should be used in storage of silage at or below grade.

Woods combining usual requirements in a *high* degree:

Lumber.—Cedar, cypress, and redwood. (When untreated, heartwood only.)

White oak. (When untreated, edge-grained heartwood only.)

Woods combining usual requirements in a *good* degree:

Lumber.—Douglas-fir, western larch, and southern yellow pine. (Treated edge-grained material preferred.)

Plywood.—Group 1 woods if preservative treated.

Woods combining usual requirements in a *fair* degree:

Lumber.—Beech, birch, eastern spruce, hemlock, northern and Idaho white pine, and ponderosa pine.

Plywood.—Cedar, redwood, Sitka and Engelmann spruce, west coast hemlock, noble fir, and white fir. (All good paint retention.) Other Group 2, 3, and 4 woods.

Grades and types used:

Lumber.—The requirements for silos, tanks, and vats are best met by grades prepared especially for these uses. Such special grades are sold as tank, tank and boat, or silo stock, and are available in most of the softwoods well adapted to these uses. The clear-heart grades available in cypress and redwood also are used extensively where requirements are high. There are no special grades in hardwoods for silos, tanks, or vats. Hardwoods, when used, should be bought on special order calling for all-heart, tight stock.

Plywood.—If the silo or other structure is to be painted, use paper-overlaid plywood. If the structure is to be stained, use Exterior, B-C, for higher quality structures, Exterior, C-C plugged, for lower cost buildings.

SHEATHING PAPERS, VAPOR BARRIERS, AND OTHER SHEET MATERIALS

Sheathing paper and vapor barriers have several general uses in the construction of houses and other frame buildings. For example, sheathing paper resists moisture and wind infiltration when used over unsheathed walls, over lumber sheathing, over all types of sheathing materials with a stucco exterior finish, and as backing for masonry veneer. The paper for such purposes should be waterproof but of the "breathing" type. This allows any escaped water vapor to move through the paper and minimizes condensation problems. Many types of materials are available for this use, including 15-pound asphalt-saturated felt.

Paper (15- or 30-pound felt) is also used as a roof underlayment for asphalt shingles when roof slopes are less than 7 in 12. Such protection is usually not needed under wood shingles except as an eave flashing to prevent moisture entry from ice dams.

Roll roofing in 45-pound and heavier weights may be used for roofing small buildings and temporary structures. Built-up roofing, consisting of a number of plies of 15- and 30-pound asphalt-saturated felt, is used on low-pitch or flat roofs. For wood decks, a nailed sheet is placed over the deck before installing alternate layers of felt and asphalt or pitch. This type of roof is usually topped with gravel or crushed stone.

Paper or deadening felt is often desirable under finish floor, as it will stop a certain amount of dust and deaden the transfer of sound.

Vapor barriers are used in walls, floors, and ceilings, usually in conjunction with insulation, to minimize the movement of water vapor to cold, exposed surfaces. They are effective in livestock barns as well as dwellings. Vapor barriers consist of plastic films, laminated or coated papers, or aluminum foil. For protection from cold weather condensation, they should be applied as close to the inner warm surface as possible, usually just under the interior coverings. They are also used under concrete slabs to prevent ground moisture from coming through.

Vapor barriers are also used as ground covers in crawl spaces to prevent wood framing and other wood materials from becoming damp from ground moisture. These barrier materials consist of duplex paper with asphalt laminate, plastic films, aluminum foil backed with paper, roll roofing, and various combinations of materials.

Product Standards

A number of quality standards have been developed to insure the quality of wood-based products used in the construction of houses and other wood-frame construction. For example, a quality control policy covers the fabrication of plywood components, and an inspection manual is available for structural glued-laminated wood members. Similar standards, such as manufacturers' procedures, provide some control in the production of various manufactured items.

Another system of controlling quality in various materials and fabricated units is through National Product Standards (formerly Commercial Standards). These standards, published by the U.S. Department of Commerce, establish quality levels for manufactured products in accordance with the principal demands of the trade. They give technical requirements for materials, construction, dimensions, tolerances, testing, and other details to promote sound commercial practices in the manufacture, marketing, and application of the products. The standards are developed by voluntary coopera-

tion among manufacturers, distributors, consumers, and other interests.

Many Product Standards relate to wood and wood-based materials. A comprehensive listing is issued by the Office of Engineering Standards Services, Bureau of Standards, U.S. Department of Commerce, Washington, D.C. 20234. The following illustrates typical listings:

NO.	LUMBER AND WOOD PRODUCTS
C.S. 31–52	Wood shingles (redcedar, tidewater red cypress, and California redwood)
P.S. 1–66	Softwood plywood, construction and industrial
C.S. 160–49	Wood-fiber blanket insulation (for building construction)
C.S. 235–61	Pressure-treated wood fenceposts (with oil-type preservative)
C.S. 236–61	Mat-formed wood particleboard (Interior use)
P.S. 20–27	American Softwood Lumber Standard
	MILLWORK
C.S. 190–64	Double-hung wood window units
C.S. 120–58	Ponderosa pine doors
P.S. 32–70	Hinged interior wood door units

Classification Of Woods According To Important Properties [4]

The choice of one wood species in preference to another for any of the principal home or farm uses should seldom be based on a single vital property. Usually a favorable combination of two or more basic qualities or characteristics should determine the selection.

In table 1 the various woods are classified according to a number of these important properties. This table is helpful when a wood is not listed for a specific use or if it departs markedly from the general classification previously outlined. Class A, in table 1, includes woods that are relatively high in the specific property or characteristic listed; class B woods are intermediate in the specific property or characteristic listed; and class C woods are relatively low.

For example, Class A in columns 2 to 16 indicates species that are generally the most desirable from the standpoint of working and behavior characteristics and strength. In columns 17 to 21, class A indicates species with the most desirable qualities because it designates greater freedom from knots and other characteristics, and greater acceptability as to their size.

Such a general classification necessarily ignores small differences and sacrifices detail in favor of the simplicity desired by the ordinary user. All woods in the same class are by no means equal, and no attempt is made to draw fine distinctions between the species.

For the different kinds (species) of wood, table 1 assumes equal size, equal dryness, and, for strength properties, an equal number of knots and other strength-reducing characteristics. So far as cross-sectional dimensions are concerned, in actual practice the different species of softwood lumber are all governed by trade standards.

Standard sizes for boards and dimension are larger for lumber surfaced green than lumber surfaced dry. When lumber surfaced green dries to the standard dry moisture content, it will shrink to approximately the standard dry surfaced size.

Most hardwoods differ substantially from softwoods in their properties (basic characteristics) and in their uses. As a class, hardwoods are heavier, harder, shrink more, and are tougher. Hardwoods and softwoods are similar in stiffness, so on a weight basis the softwoods are actually much stiffer. In strength as a post and in bending strength the two groups are more directly comparable than they are in weight, toughness, and hardness; nevertheless, more commercial hardwoods than softwoods can be rated high in bending strength.

The softwoods are used principally in construction work, whereas hardwoods furnish most of the wood for interior finish and flooring as well as for implements, furniture, and other industrial uses. In addition to normal construction uses, 2-inch and thicker lumber is also sold stress-graded for more carefully engineered components such as trusses.

The various properties and characteristics as designated in table 1 are more fully described in the following sections.

Hardness

Hardness (table 1, column 2) is the property that makes a surface difficult to dent, scratch, or cut. Generally, the harder the wood, the better it resists wear, the less it crushes or mashes under loads, and the better it can be polished. On the other hand, the harder wood is more difficult to cut with tools, harder to nail, and more likely to split in nailing.

Hardness is of particular concern in flooring, furniture, and tool handles. Hardness is also important in selecting interior trim such as door casings, base, and base shoe, as well as door jambs, sills, and thresholds. These portions usually receive the hardest wear in a house.

[4] See definition of properties as used in this bulletin on p. 3.

There is a pronounced difference in hardness between the springwood and the summerwood of woods such as southern yellow pine and Douglas-fir. In these woods the summerwood is the denser, darker colored portion of the annual growth ring. Differences in surface hardness thus occur at close intervals on a piece of such wood depending on whether springwood or summerwood is encountered. In woods like maple, which do not have pronounced springwood and summerwood, the hardness of the surface is quite uniform.

The classification of a species as a hardwood or softwood is not based on actual hardness of wood. Technically, softwoods are those cut from coniferous or evergreen trees, whereas hardwoods are those cut from broad-leaved and deciduous trees. Actually, some of the softwoods are harder than some of the hardwoods.

As a group, the hardwoods can be divided into (a) dense and (b) less dense. The softwoods can also be divided into two groups: (a) medium-density and (b) low-density.

A number of woods are strong favorites for building purposes largely because of their softness and uniformity rather than their hardness. Northern white pine (eastern) and Idaho white pine (western), poplar, white fir, and basswood are traditional examples. Others are ponderosa pine, sugar pine, and cedar. The ease with which these woods can be cut, sawed, and nailed has put them in a high position for general use. This is less important in present-day construction because portable power tools make it easier to handle such dense species as Douglas-fir and southern yellow pine. In fact, the use of these denser species allows greater spans for joists and rafters than can be used for equal-sized members of the softer woods.

Differences in hardness are great enough to affect the choice of woods for such uses as flooring and furniture on one hand, and for siding, millwork, and cabinets on the other.

Weight

Weight, in addition to being important in itself, is generally a reliable index of strength. A heavy piece of wood is generally stronger than a lighter piece of the same moisture content and size, whether it is of the same or of a different species.

Wood weights, as commonly expressed, are either in the green or in the air-dry condition. Green weight of wood is the weight before any drying takes place; air-dry weight of wood refers to the weight after drying by exposure to atmospheric conditions for a time, either outdoors or in unheated sheds. The classification in table 1, column 3, is based on the air-dry condition.

Freedom From Shrinkage and Swelling

Most materials change in dimension with changes in temperature or moisture. Wood, like many other fibrous materials, shrinks as it dries and swells as it absorbs moisture. As a rule, however, much shrinking and swelling of wood in structures can be avoided by using wood that has been dried to a suitable moisture content.

For most species, the shrinkage or swelling in width of a flat-grained or plainsawed board [5] is often approximately twice that of an edge-grained or quartersawed board [5] of the same width (see fig. 4). Edge-grained boards or other items cut from a species with high shrinkage characteristics will therefore prove as satisfactory as flat-grained boards or items cut from species with lower shrinkage characteristics. The normal wood of all species shrinks or swells very slightly along the grain (lengthwise).

The classification according to the amount of shrinkage (table 1, column 4) generally compares the performance of woods of various species. It does not tell the user the whole story of the shrinking and swelling of different species in service. Shrinkage of wood begins when moisture in the wood is removed by drying below the fiber saturation point (approximately 30 percent moisture content). When wood reaches a moisture content of 15 percent, about one-half of the total shrinkage has occurred. The moisture content of wood in service constantly changes since it adjusts to corresponding changes in surrounding atmospheric conditions.

The moisture content of woodwork installed within heated buildings reaches a low point during the heating season and a high point during the summer. The moisture content at the time of installation should be near the midpoint of this range. If this rule is followed, slight shrinkage will occur during some seasons and a slight swelling during others.

In a large portion of the United States, moisture content of interior woodwork in use varies between 5 and 10 percent with an average of about 8 percent. Siding and exterior trim in this same area varies between 9 and 14 percent, averaging about 12 percent. The dry southwest areas average below these percentages and the damp southern coastal States average above.

Plywood is relatively free from shrinkage and swelling as compared to solid wood because its construction generally consists of alternate laminations of veneers laid with grain at 90° to

[5] Lumber that is cut tangent (roughly parallel) to the annual growth rings of the tree produces plainsawed boards in hardwoods and flat-grained or slash-grained boards in softwoods. Lumber that is cut at right angles to the annual rings, or parallel to the radius of the log, produces quartersawed boards in hardwoods, and edge-grained or vertical-grained boards in softwoods.

TABLE 1.—*Broad classification of woods according to characteristics and listed; B, among woods intermediate in that respect; C, among*

Kind of wood	Working and behavior characteristics											Strength properties			
	Hardness	Weight, dry	Freedom from shrinkage and swelling	Freedom from warping	Ease of working	Paint holding[1]	Nail holding	Decay resistance of heartwood	Proportion of heartwood[2]	Amount of figure	Freedom from odor and taste (dry)	Bending strength[3]	Stiffness[3]	Strength as a post	Toughness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ash: Black	B	B	C	B	C	C	A	C	C	A	A	B	B	C	A
White	A	A	B	B	C	C	A	C	C	A	A	A	A	A	A
Aspen	C	C	B	B	A	A	C	C	B	C	A	C	B	C	C
Basswood	C	C	C	B	A	A	C	C	C	C	A	C	B	C	C
Beech	A	A	C	C	C	B	A	C	B	B	A	A	A	B	A
Birch	B	A	C	B	C	B	A	C	C	B	A	A	A	B	A
Cedar: Eastern red	B	B	A	A	B	A	B	A	B	B	C	B	C	B	B
Northern white	C	C	A	A	A	A	C	A	A	C	B	C	C	C	C
Southern white	C	C	A	A	A	A	C	A	A	C	B	C	C	C	C
Western red	C	C	A	A	A	A	C	A	A	B	C	C	C	B	C
Cherry	B	B	B	A	B	B	A	C	B	B	B	A	A	A	B
Cottonwood	C	C	B	C	B	A	C	C	C	C	B	C	B	C	C
Cypress	B	B	A	B	B	A	B	A	B	A	B	B	B	B	C
Douglas-fir	B	B	B	B	B	B	A	B	A	A	C	A	A	A	B
Elm: Rock	A	A	B	B	C	C	A	C	B	A	A	A	A	A	A
Soft	B	B	B	C	C	C	A	C	B	A	A	B	B	B	A
Fir: Balsam	C	C	B	B	B	C	C	C	B	C	A	C	C	C	C
White	C	C	A	B	B	C	C	C	C	C	A	B	A	B	C
Gum	B	B	C	C	B	C	A	B	B	B	B	B	A	B	B
Hackberry	B	B	C	B	C	C	A	C	C	A	A	B	C	C	A
Hemlock: Eastern	B	C	A	B	B	B	B	C	B	B	A	B	B	B	C
West coast	B	C	B	B	B	B	B	C	B	B	A	B	A	B	B
Hickory	A	A	C	B	C	C	A	C	B	B	B	A	A	A	A
Larch: Western	B	A	B	B	C	C	A	B	A	A	C	A	A	A	B
Locust	A	A	A	B	C	C	A	A	A	A	B	A	A	A	A
Magnolia	B	B	B	B	B	B	A	C	B	B	B	B	B	B	B
Maple: Hard	A	A	C	B	C	B	A	C	C	B	A	A	A	A	A
Soft	B	B	B	B	C	B	A	C	C	B	A	B	B	B	B
Oak: Red	A	A	B	B	C	C	A	C	B	A	B	A	A	B	A
White	A	A	C	B	C	C	A	A	B	A	B	A	A	B	A
Pecan	A	A	B	B	C	C	A	C	B	B	B	A	A	A	A
Pine: Idaho white (western)	C	C	B	A	A	A	C	C	B	C	C	B	B	B	C
Lodgepole	C	C	B	C	B	C	B	C	B	C	C	B	B	B	C
Northern white (eastern)	C	C	A	A	A	A	C	B	B	C	C	C	C	C	C
Ponderosa	C	C	A	A	A	B	B	C	C	C	C	C	C	C	C
Southern yellow	B	A	B	B	B	C	A	B	C	A	C	A	A	A	B
Sugar	C	C	A	A	A	A	C	C	B	C	C	C	C	C	C
Poplar	C	B	B	A	B	A	B	C	B	B	A	B	B	B	B
Redwood	B	C	A	A	B	A	B	A	A	B	A	B	B	A	C
Spruce: Eastern	C	C	B	A	B	B	B	C	C	B	A	B	B	B	C
Engelmann	C	C	A	A	B	B	C	C	C	B	A	C	C	C	C
Sitka	C	C	B	A	B	B	B	C	C	B	A	B	A	B	B
Sycamore	B	B	B	C	C	B	A	C	B	B	A	B	B	B	B
Tupelo	B	B	B	C	C	B	A	C	C	C	A	B	B	B	B
Walnut	B	A	B	A	B	C	A	A	B	B	A	A	A	A	A

[1] Indicates general paintability and performance characteristics of edge-grained surfaces exposed to the weather.

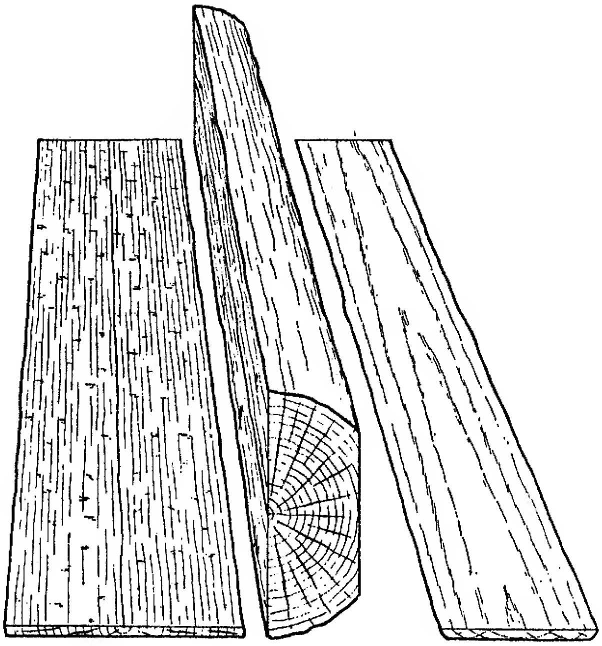
[2] Exclusive of the all-heartwood grades that are available on special order in birch, cedar, cypress, Douglas-fir, gum, southern yellow pine, redwood, and walnut.

[3] Many of the softwood species are sold stress-graded for greater strength and stiffness.

Note: This table does not include all domestic species that can be obtained commercially. Characteristics of additional species can be found in the "Wood Handbook," Agriculture Handbook No. 72.

properties (A, among the woods relatively high in the particular respect woods relatively low in that respect. Letters do not refer to lumber grades).

Surface characteristics of common grades					
Knots		Pitch defects	Other defects		
Freedom from	Acceptance as to size	Freedom from	Freedom from	Acceptance as to size	Distinctive and principal uses
17	18	19	20	21	22
A	B	A	B	B	Implements, cooperage, containers, furniture
A	B	A	B	B	Implements, containers, furniture, veneer
A	A	A	B	B	Boxes, lumber, pulp, excelsior, veneer
A	B	A	A	A	Woodenware, boxes, veneer, excelsior, lumber
B	B	A	C	C	Flooring, furniture, woodenware, cooperage, veneer
A	B	A	B	B	Flooring, furniture, millwork, veneer
C	A	A	A	A	Posts, paneling, wardrobes, chests
B	B	A	B	B	Poles, posts, tanks, woodenware
A	B	A	A	A	Posts, poles, boat and tank stock, shingles, woodenware
A	C	A	B	B	Shingles, siding, poles, millwork, boats, paneling
A	B	A	B	B	Furniture, woodenware, paneling, gunstocks
A	A	A	A	A	Pulpwood, excelsior, containers, woodenware, lumber, veneer
A	B	A	B	B	Millwork, siding, tanks, cooling towers, poles, shakes
B	B	B	B	B	Construction, plywood, millwork, flooring, piling, poles
B	B	A	B	B	Furniture, containers, veneer, cooperage
B	B	A	C	C	Containers, furniture, veneer
C	A	A	B	B	Light construction, pulpwood
B	B	A	B	C	Light construction, containers, millwork
A	B	A	A	A	Millwork, containers, furniture, veneer, pulpwood
A	C	A	B	B	Furniture, veneer, containers
B	B	A	C	C	Construction, containers, pulpwood
B	B	A	B	B	Construction, pulpwood, containers, flooring
B	C	A	B	B	Handles, athletic goods, implements, flooring
C	A	A	C	A	Construction, poles, ties, millwork
B	B	A	B	B	Poles, posts, insulator pins, ties, fuel, containers
A	B	A	B	B	Furniture, veneer, containers, millwork
B	B	A	B	B	Flooring, furniture, veneer, woodenware
A	B	A	A	A	Furniture, woodenware, fuel, pulpwood
A	C	A	B	B	Flooring, furniture, veneer, posts, millwork
A	C	A	B	B	Furniture, cooperage, millwork, veneer, flooring, implements
A	C	A	C	C	Implement handles, flooring, pallets
C	A	A	C	A	Millwork, construction, siding, paneling, containers
C	B	A	B	B	Poles, lumber, ties, mine timbers
C	A	A	B	B	Millwork, furniture, containers, paneling, siding
B	B	B	B	B	Millwork, construction, poles, veneer, paneling
A	C	C	B	B	Construction, poles, siding, cooperage, ties, plywood
C	B	A	B	A	Millwork, patterns, construction, containers, siding
A	B	A	A	A	Furniture, plywood, containers, pulpwood, excelsior
A	C	A	A	B	Siding, tanks, millwork, cooling towers, outdoor furniture
C	A	A	B	B	Construction, pulpwood, millwork, containers
C	A	A	B	B	Light construction, poles, pulpwood, mine timbers
B	B	A	B	B	Construction, millwork, containers, pulpwood, cooperage
A	B	A	B	B	Furniture, veneer, cooperage, containers
A	A	A	A	A	Containers, furniture, veneer, cooperage
A	B	A	A	A	Furniture, gunstocks, interior finish, veneer



A B

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FIGURE 4.—Grain depends on how lumber is cut from log. Board "A" is quartersawed or edge-grained. Board "B" is plainsawed or flat-grained.

each other. From soaked to ovendry condition, the shrinkage of plywood in length and width is generally quite uniform and ranges from only about 0.2 to about 1.2 percent. After manufacture, plywood has a low moisture content and normally does not require drying out before use.

Methods of determining whether wood is dry enough for use are discussed later (see p. 34).

Freedom From Warping

The warping of wood is closely allied with shrinkage. Lumber that is crossgrained, or is from near the pith (core) of the tree, tends to warp when it shrinks. Classification of species according to their tendencies to warp and twist during seasoning, and as a result of changes in atmospheric conditions once the wood is dry, is listed in table 1, column 5. Warping can be reduced to a minimum by the use of edge-grained dry material.

The combined characteristics of warping and shrinkage determine the ability of wood to remain flat, straight, and not change size while in use. These qualities are desired in practically all uses. They are especially important in furniture, cabinetwork, window sash and frames, doors, and siding. Proper seasoning is important, but good construction details outlined later for preventing shrinkage also effectively prevent warping.

Ease of Working

Wood is generally easy to cut, shape, and fasten with ordinary tools directly on the building site. For some purposes the difference between woods in ease of working is negligible, but for others it may decidedly affect the quality and cost of the finished job. In general, ease of working is of first importance to the worker and indirectly to the one who pays the bill. Fabrication and assembly at the factory of cabinets, windows, frames, doors, and other units have greatly reduced the time required for the skilled worker at the building site.

Harder and denser woods with high load-carrying capacity and wear resistance should not be passed over just because softer woods are easier to work; rather, a reasonable balance must be drawn in selecting wood for a specific use.

A skilled carpenter working with lumber that is well seasoned and manufactured can get good results from even the more difficult-to-work woods. An unskilled worker is more likely to get good results only from the softer woods. However, with portable power tools, jigs for installation of hinges and door locks, and other modern labor-saving methods, skill is no longer the major factor it was when hand tools were the only means of cutting and fitting on the job.

The classification of the more common woods according to their working qualities (table 1, column 6) is based on a combination of the hardness, texture, and character of the surfaces obtainable. Woods in the A class have soft, uniform textures and finish to smooth surfaces; woods in the C class are hard or nonuniform in texture and more difficult to surface without chipping the grain, fuzzing, or grain raising. The B class is intermediate.

Paint Holding

Good paint performance or ability of a wood surface to hold paint depends on three factors: (1) the kind of paint, (2) surface conditions and application factors, and (3) the kind of wood. The first two factors are discussed later under the section "How and When to Paint" (p. 41); only the kind of wood is discussed at this point.

Different woods vary considerably in painting characteristics, particularly for outdoor exposure. The ratings of the species in table 1, column 7, indicate generally their abilities to hold paint under exposure to the weather. The best species for exterior painting are the woods in A class, including such common ones as the cedars, redwood, ponderosa pine, or white pine.

Paint is more durable on edge-grained surfaces than on flat-grained surfaces. The edge-grained boards in B class woods usually have a

better surface for painting than the flat-grained surfaces of A class woods.

Knots, particularly resinous ones, do not hold paint well and contribute to abnormally early paint failure. High content of pitch and resin will also detract from the paintability of wood unless the pitch is set adequately by proper high-temperature seasoning of the wood.

Class B and class C woods and plywood are best finished with pigmented stains that penetrate the wood surface and do not form a continuous film on the surface. Such stain finishes do not fail by cracking and peeling of the coating from the wood as does paint. The stains are also recommended for use on shingle and shake sidewalls and rough-sawn lumber and siding.

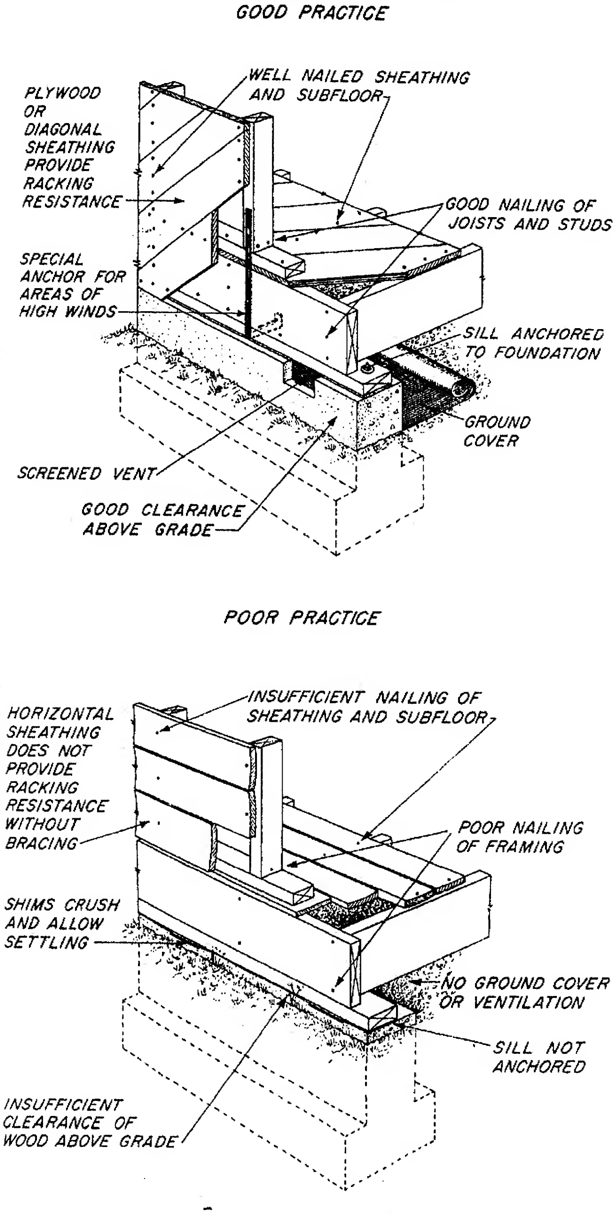

FIGURE 5.—Good and poor construction practices at foundation.

Nail Holding

As a rule, fastenings are the weakest link in all forms of construction and in all materials; therefore the resistance offered by the wood to the withddrawal of nails is important. Usually, the denser and harder the wood, the greater is the inherent nail-holding ability, assuming the wood does not split. The grouping of the commercial woods (table 1, column 8) according to their inherent nail-holding ability is based on tests that measured the force required to pull nails from wood.

The size, type, and number of nails have a marked effect on the strength of a joint. Figure 5 illustrates good and poor nailing practices at the foundation wall. Correct placement of the nails is as important as the size and number. If high winds are general during severe storms, special fastenings should be used to resist these pressures.

The resistance of nails to withdrawal increases almost directly with their diameter; if the diameter of the nail is doubled, the holding strength is doubled, providing the nail does not split the wood when it is driven. The lateral resistance of nails increases as the 1½ power of the diameter.

The nail most generally used in wood-frame construction is the common nail. However, galvanized and aluminum nails are used extensively in applying siding and exterior trim because these nails resist rusting. The galvanized nail is slightly better than the common bright nail in retaining its withdrawal resistance.

Superior withdrawal resistance has been shown by the deformed-shank nail, which is produced in two general forms, the annular-groove and the spiral-groove shanks. The annular-groove nail is outstanding in its resistance to static-withdrawal loads but not as good as the spiral-groove nail when subjected to racking loads. The spiral-groove nail is superior to the plain-shank nail in its resistance to withdrawal loads and is commonly used in construction of pole-type buildings.

Interior carpentry uses the small-headed finish nail, which can be set and puttied over.

The moisture content of the wood at the time of nailing is extremely important for good nail holding. If plain-shank nails are driven into wet wood, they will lose about three-fourths of their full holding ability when the wood becomes dry. This loss of holding power is so great that siding, barn boards, or fence pickets are likely to become loose when plain-shank nails are driven into green wood that subsequently dries. Thus the most important rule in obtaining good joints and high nail-holding ability is to use well-seasoned wood.

Prevention of Splitting.—The splitting of

wood by nails greatly reduces their holding ability. Even if the wood is split only slightly around the nail, considerable holding strength is lost. Because of hardness and texture characteristics, some woods split more in nailing than do others. The heavy, dense woods, such as maple, oak, and hickory, split more in nailing than do the lightweight woods such as basswood, spruce, and balsam and white fir.

Predrilling is good practice in dense woods, especially when large diameter nails are used. The drilled hole should be about 75 percent of the nail diameter.

Woods without a uniform texture, like southern yellow pine and Douglas-fir, split more than do such uniform-textured woods as northern and Idaho white pine, sugar pine, or ponderosa pine.

In addition to predrilling, the most common means taken to reduce splitting is the use of small diameter nails. The number of small nails must be increased to maintain the same gross holding strength as with larger nails. Slightly blunt-pointed nails have less tendency to split wood than do sharp-pointed nails. Too much blunting, however, results in a loss of holding ability.

Decay Resistance

Every material has its distinctive way of deteriorating under adverse conditions. With wood it is decay. Wood will never decay if kept continuously dry or continuously under water. Fortunately, most wood in ordinary buildings is in dry situations and therefore not in danger of decay. It is only in certain parts of the buildings that decay resistance is important, such as areas where wood may become damp or where it touches or is embedded in the ground.

To protect wood from decay, there are three things which can be done, either singly or in combination: (1) make sure it is dry when installed and kept dry in service; (2) use the heartwood of a decay-resistant species where occasional wetting and drying can be expected; or (3) use wood that has been given a good preservative treatment for places where moisture is certain to get in, as from contact with the soil or because of poor drainage or ventilation.

The different kinds of wood are classified in accordance with their natural decay resistance in table 1, column 9. This classification applies solely to the heartwood, because sapwood of all species in the untreated condition has low decay resistance. Also, this classification deals only with averages, and exceptions frequently occur because of variations in the wood itself and because of differences in the kinds of fungi that cause the decay.

Further information on avoiding decay, including the use of preservative-treated material, is contained in the later section on "Preventing Decay" (p. 38).

Proportion of Heartwood

When selecting untreated wood for use where the decay hazard is high, one must consider the heartwood content, because only the heartwood is decay resistant. When the sapwood of the species of tree is normally narrow, as it is in the woods rated as class A in table 1, column 10, the lumber runs high in heartwood content even without special selection. When the sapwood is normally wide, as in woods rated as class C and even in class B in column 10, the commercial run of lumber contains considerable sapwood.

To obtain decay-resistant lumber, even in the species classed as A in decay resistance in column 9, it is necessary to eliminate the sapwood by special selection. Specially selected building lumber, sold in "all-heart" grades, is procurable in cypress, redwood, western red cedar, and Douglas-fir. However, all-heart grades in southern yellow pine are special and are not easily obtainable.

Figure

Figure is due to various causes in different woods. In woods like southern yellow pine and Douglas-fir, it results from the contrast between springwood and summerwood in growth rings; in oak, beech, or sycamore, it results from the flakes or rays in addition to the growth rings; in maple, walnut, and birch it results from wavy or curly grain; and in gum it results from infiltrated coloring matter.

Except where the figure in wood results from flakes or rays, it is more pronounced in flat-grained lumber than in edge-grained. Figure resulting from wavy or curly grain or from infiltrated color does not occur in all lumber of a given species, but only in lumber from occasional logs. To be certain of getting figured lumber in maple, walnut, or gum, special selection is necessary.

Woods with outstanding knots, such as pine and cedar, or with other unique characteristics such as those of pecky cypress, or "white speck" Douglas-fir, are often selected because of their novel patterns. The finish selected for these types of wood tends to accentuate rather than obscure the knots or other features. The advantage of figure or color may appear in the interior trim, in the floor, or in a wood-paneled wall.

The color of the wood has a decided influence on the figure. However, stains are so commonly and easily applied to most woods that natural color is usually not the first consideration, except where a very light color is desired.

A broad classification of the important kinds of lumber, from the standpoint of the amount of

figure they contain, is shown in table 1, column 11. Woods classed as A are highly figured, and an ordinary commercial run will have a pronounced figure. Class B woods have more modulated figures and sometimes require special selection to obtain the desired figure. Class C woods are seldom satisfactory where figure is desired.

Freedom From Odor and Taste When Dry

None of the common woods has sufficient odor to prevent its satisfactory use in building construction. It is only when the wood is used for food containers that odor and taste are critical. When green, all woods have some odor and will impart a woody taste to very susceptible foods. After the woods are dried, however, many have practically no odor or taste. The principal objection to odor and taste in wood is that they contaminate food they touch, especially butter and cheese. On the desirable side, the aromatic odor of the cedars is prized for such uses as clothes closets and chests.

The woods grouped in class A in table 1, column 12, are suitable for use in contact with foods that absorb odors. The woods in class C have a strong resinous or aromatic odor and are unsuited for use in direct contact with foods that absorb odors. Woods in class B cannot be used in contact with very susceptible foods, like butter, but they do not have the strong odor and taste of the aromatic and resinous woods.

Bending Strength

Bending strength is a measure of the load-carrying capacity of members that are ordinarily used in a horizontal or moderate slope position and rest on two or more supports. Examples of members in which bending strength is important are rafters, ceiling and floor joists, beams or girders, purlins, bridge stringers, and scaffold platforms.

Methods that can be used without grading experience to select lumber for bending strength are given in U.S. Department of Agriculture Leaflet 481, "Selecting Farm Framing Lumber for Strength" (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 5 cents.) The selection will eliminate the weakest pieces, which make up about 20 to 25 percent of a normal lot of ungraded lumber.

Even though a species is low in bending strength, it may still be selected for uses where this property is essential. However, larger sizes are then required to obtain the same load-carrying capacity.

A small increase in the depth of a beam produces a much greater percentage increase in bending strength than it does in volume. An increase of 1 inch in the depth of a 10-inch beam (from 10 to 11 inches) will increase its volume 10 percent, whereas the bending strength of the beam is increased 21 percent. An increase in the width of a beam, however, increases the bending strength by the same percentage as the volume. An increase of 1 inch in a beam 10 inches deep will increase both bending strength and volume by 10 percent.

No simple rule can be given to determine the size of girder, joist, or plank required to carry a given load. However, lumber associations have prepared books that contain tables of safe loads for given spans, sizes, species, and spacings.

Span tables for joists and rafters made from American Standard softwood lumber are available from National Forest Products Association, 1619 Massachusetts Ave., N.W., Washington, D.C. 20006. Methods used to calculate the size of wood members subjected to bending loads are given in Agriculture Handbook No. 72.

The softwoods in class A in table 1, column 13, such as Douglas-fir, southern yellow pine, and western larch, dominate the structural field. They are used both for heavy construction (barns and bridges) and light construction (dwellings and small farm structures). In heavy construction, softwoods in class B are used only occasionally. In light construction, softwoods in class B such as white fir, hemlock, and Idaho white pine are used extensively. Their light weight and ease of working enable them to compete with the stronger woods.

Woods in class C are relatively unimportant in the structural field as they are seldom used in heavy construction and only occasionally in light construction. The hardwoods in classes A and B have largely dropped out of the construction field, not because they are unsuited to the use, but because of their value for uses with more exact requirements—furniture, flooring, and veneers in plywood.

Stiffness

Stiffness is a measure of the resistance to bending or deflection under a load. In the floor and ceiling joists of a house, stiffness is more important than actual breaking strength,[6] because it is deflection or sag that must be reduced to a minimum to avoid plaster cracks in ceilings and vibration in floors. Stiffness is important also in shelving, ladder rails, beams, and long, slender columns.

Whereas stiffness is of great importance in floor joists, the advantages of using a relatively stiff species will be lost if the members are not fully dry at time of installation, so the fastenings and bracing hold well. Straight, well-seasoned joists of a species that is relatively low

[6] Breaking strength refers to the load required to break a material, while stiffness refers to its ability to sustain loads with a minimum of deflection or sag.

in stiffness may give better results than an inherently stiff wood that is green or carelessly installed. If the wood is sufficiently dry and the installation is good, however, species differences with respect to stiffness are important.

Differences in stiffness between species may be compensated for by changing the size of members. Depth and length of members have a greater effect on their stiffness than on other strength properties. For example, a change of 1/32 inch in the thickness of a 25/32-inch board produces a change of 12 percent in the stiffness of the board laid flat in a floor. A 10-inch joist has about one-fourth more wood in it than an 8-inch joist, but set on edge in a building it is more than twice as stiff.

The species are classified by stiffness in table 1, column 14. Softwoods in class A and class B dominate the uses where stiffness is the most important requirement. When woods in class C are used where stiffness is desired, it is because other properties are more important. The woods in class A have the highest stiffness, but they are heavier and harder than those in Class B.

Light weight is quite commonly desired in combination with stiffness. The softwoods meet this requirement much better than the hardwoods, and softwoods in class B are often chosen in preference to those in class A because the weight of the latter excludes them.

Strength as a Post

Posts or "compression members" are generally square or circular in cross section, usually upright, and support loads that act in the direction of the length. Strength in compression is an essential requirement for posts supporting beams in a basement or crawl space, for supports of root cellars, for storage bins, and for posts in similar heavy construction where the length is less than 11 times the smallest dimension. It is not important in fenceposts, which carry no loads.

In small buildings the size requirements of posts, with the smallest dimension less than one-eleventh of the length, are determined by bearing area, stiffness, and stability, rather than by actual compressive strength. Therefore it is necessary to use posts large enough to carry much greater compressive loads than are ever placed upon them. No great consideration need therefore be given to compressive strength endwise in selecting wood for small houses.

Where exceptionally heavy loads are involved, as in supports for bins or underground cellars, consideration should be given to the compressive strength of different woods as shown in table 1, column 15. Even where compressive strength is an important requirement, the woods in any class may be safely used, provided the lower strength of class B and C woods is compensated for by using timber of larger cross-sectional area.

When the length of the post or column is greater than 11 times the smallest dimension, stiffness becomes an important factor in determining the load-carrying ability. Unbraced supports, such as squared posts in machine sheds or barns and poles in pole-type structures, are generally so slender that they should be judged by their stiffness rather than their compressive strength.

Toughness

Toughness is a measure of the capacity to withstand suddenly applied loads. Hence, woods high in shock resistance are adapted to withstand repeated shocks, jars, jolts, and blows, such as are given ax handles and other tool handles. The heavier hardwoods—hickory, birch, oak, maple, and ash—are so much higher in shock resistance than the toughest of the softwoods that these hardwoods are used almost exclusively where an exceptionally tough wood is required.

None of the softwoods in table 1, column 16, is grouped in class A in toughness, and few hardwoods (aspen, cottonwood, and basswood) fall in class C. The woods in class A completely dominate the uses where toughness is the outstanding requirement, and hickory dominates class A.

Toughness is a desirable property in uses other than those in which it is required. Tough woods give more warning of failure than do brash woods. It is, therefore, a factor in beams and girders where heavy loads are applied. The selection of class C woods should normally be avoided for these two uses.

Surface Characteristics of Common Grades of Lumber

Lumber is purchased by home owners because of its appearance as well as its working characteristics and strength properties. The appearance is dependent largely on the grade, and there is some degree of uniformity in the appearance of the same grade in different woods. Different woods are more uniform in appearance in the Select grades than in Common or Dimension grades because most knots, pitch pockets, and the like are eliminated from the Select grades.

In the Common grades, however, where knots and similar surface features are allowable, there are differences in the same grade of different

woods. These differences affect the appearance of the wood and at times its suitability for a use. For example, the number of knots and like features in a board averages, in different species, from about 5 to 20 per 8 board feet regardless of grade. Second and third grade Common Boards are selected for greatest utility. Fourth and lower grades permit moderate utility. Grades for the various species for Board and Dimension lumber are outlined in a following section.

Table 1, therefore, includes in columns 17 to 21 a classification of various woods according to the size and number of the more important surface features found in the Common grades. The woods classed as A have the least number of these surface features and are generally the most desirable. Those classed as C have the most knots and other surface features and are generally not as desirable, unless these features are used for an architectural or decorative effect such as knotty paneling. (These letters do not correspond to lumber grades.)

Distinctive and Principal uses

The distinctive and principal uses to which a wood is put are indicative of its properties. Distinctive and principal uses are those to which a wood is most generally fitted. The fact that a wood's distinctive use is for gunstocks, for ax handles, for woodenware, or for fenceposts tells one who is familiar with these uses much more about the wood than does a verbal description or a table of properties, unless he has been trained to combine and evaluate the properties. A knowledge of the requirements for ax handles obtained from actual experience gives a good idea of the combination of toughness, breaking strength, stiffness, and texture to be found in a wood used for that purpose.

The distinctive and principal uses listed in table 1, column 22, therefore supplement the data on properties and aid in visualizing the general character of the wood.

Lumber Grades

Lumber grading rules are formulated and published by associations of lumber manufacturers or by official grading and inspection bureaus.

Softwood Lumber

Finish or Select grades.—Finish or Select grades of lumber generally are named by the letters A, B, C, and D. The A and B grades are nearly always combined as B and Better, so that only three grades are in practical use.

Thus, in lumber for interior and exterior finishing or other similar uses, only B and Better (first grade), C (second grade), and D (third grade) in softwoods need to be considered. However, considerable knotty pine and cedar in third grade are selected for use as paneling.

Common boards.—Grade names for common boards are not uniform for all softwood species. For example, in redwood boards Select is the first grade, Construction the second, Merchantable the third, and Economy the fourth. With such woods as Douglas-fir, west coast hemlock, Sitka spruce, and western redcedar, the grade designations are Select Merchantable, Construction, Standard, Utility, and Economy. A different set of board grades described by the Western Wood Products Association bears the names 1 Common, 2 Common, 3 Common, 4 Common, and 5 Common. The same set of grade names and descriptions is used in the Northeast and Lake States for species such as eastern spruce, balsam fir, red and jack pine, eastern hemlock, and northern white cedar. For the southern pines, the board designations are No. 1, No. 2, No. 3, and No. 4.

Dimension lumber.—Light Framing (2 to 4 inches thick, 2 to 4 inches wide) and Joists and Planks (2 to 4 inches thick, 6 inches and wider) are graded for strength to a common set of grade names and descriptions under all six softwood grading rules published in the United States, and under the National Lumber Grades Authority in Canada. The light framing grades are Construction, Standard, and Utility, and the Joist and Plank grades are Select Structural, No. 1, No. 2, and No. 3. There is also a Structural Light Framing category for roof truss and similar applications that has the same grade names as for Joists and Planks. Load-carrying design values vary by species and use category; therefore, it is important to note that common grade names do not imply equal strength or stiffness. The National Forest Products Association (see page 23) can be referred to for design values.

Trade practices.—It has been the practice for the lumber retailer to quote prices and make deliveries on the basis of local grade classification or on his own judgment of what the user needs or will accept. However, there is a growing practice to put indelible marks on all building lumber at the sawmill, stating the grade, species, size, degree of seasoning, and identity of

the supplier. The Federal Housing Administration (FHA) and most code authorities require that framing lumber used in the construction of FHA-insured units be so grade-marked.

The softwoods are graded to meet fairly definite building requirements. Select grades of softwoods are based on suitability for natural and paint finishes: A Select and B Select or B and Better are primarily for natural finishes, and C Select and D Select are for paint finishes. The Utility Board and Dimension grades are based primarily on their suitability for general construction and general utility purposes as influenced by the size, tightness, and soundness of knots.

Hardwood Lumber

The wood of the hardwood trees is graded on the basis of factory grades more than for building requirements. Factory grades take into account the yield and size of cuttings with one clear face that can be sawed from the lumber. The two highest factory grades are known as Firsts and Seconds, and are usually sold combined.

Hardwoods for construction are grouped into three general classes: Finish, Construction and Utility Boards, and Dimension. A Finish has one face practically clear, while B Finish allows small surface checks, mineral streaks, and other minor variations.

Construction Boards and Utility Boards have No. 1, No. 2, and No. 3 grades and are based on the amount of wane, checks, knots, and other defects present in each board.

Dimension grades (2 inches thick) are classed as No. 1 and No. 2 depending on the number of defects.

Strength Factor

The ordinary grades of building or so-called yard lumber are based on the size, number, and location of the knots, slope of grain, and the like more than on the strength of the clear wood. Common softwood boards used in conventionally constructed houses and other light-frame structures are not related directly to the strength of the unit itself. Rather, sheathing, subflooring, and roof boards supplement the framing system and may also add to the rigidity of the structure.

The main purpose of boards used in the construction of a building is as a covering material. They also facilitate nailing for siding, flooring, and roofing materals. For these purposes they must have some nail-holding properties as well as moderate strength in bending to carry loads between the frame members. Ordinarily, third and fourth grade boards are adequate for this purpose.

Finish and Select grade softwood boards are selected for their appearance rather than strength. They are used mainly for trim and finish purposes, and consequently the grade is chosen based on the type of finish used—natural, stained, or painted.

Softwood Dimension lumber is selected because of its strength and its stiffness. Therefore, the size, number, and location of knots are important and related directly to the intended use. In house floors and walls, for example, where construction is designed to minimize vibration and deflection so far as possible, stiffness rather than breaking strength is most important. Generally, grade affects strength more than stiffness; the lower the grade, the lower the strength.

Finishing and Appearance Factor

The finishing and appearance of wood is normally associated with the various Board grades rather than Dimension grades. With varnish and natural finishes, A and B Select in softwoods (commonly sold as B and Better) and A Finish in hardwoods assure the best appearance. Some pieces in the B and Better grade are practically clear, although the average board contains one or two small surface features that preclude calling it Clear.

Where the very smoothest appearance is not required, second Finish grade in softwoods and hardwoods gives good satisfaction. The number of knots, pitch pockets, and other nonclear features per board in C Select averages about twice that of B and Better; the proportion of these features that are small knots is greater in C Select than in B and Better. Because of its decorative effects, knotty lumber selected from the first and second Common board grades is frequently in demand for paneling.

For painting where wood is not exposed to the weather, the surface features permitted in the second Finish grade are such that they can be well covered by paint if the priming is properly done. The third Finish grade, with some cutting out of defects, gives almost as good quality as the second grade. Some of the natural features and manufacturing imperfections are not much more numerous in the third grade than in the second grade, but the number and size of the knots are considerably greater, and often the back of the pieces is of lower quality. Where smoothest appearance at close inspection is required under exposure to the weather, first Finish grade gives the best results.

For painted surfaces that do not receive close inspection (barns, summer cottages, and the like) and where protection against the weather is as important as appearance, the first and second Board grades are satisfactory. The larger knots and pitch pockets in the second grade Common softwood boards do not give as smooth and lasting a painted surface as do the smaller ones in the first grade, but the general utility is good.

Tightness Factor

First grade Common softwood and Utility hardwood boards are suitable for protection against rain or other free water beating or seeping through walls or similar construction. These and the Finish grades are usually kept drier at the lumber yards than are the lower grades, and will therefore shrink and open less at the joints if used without further drying. Where only tightness against leakage of small grain is required in a granary or grain bin, second grade boards may be used with a small amount of cutting to eliminate knotholes. When used as sheathing with good building paper, second grade boards are satisfactory even though knotholes and other similar openings do occur.

Wear-Resistance Factor

Edge-grained material wears better than flat grain, narrow-ringed wears better than wide-ringed, and clear wood wears more evenly than wood containing knots. The first Finish grades in softwoods and hardwoods ordinarily contain very few defects and withstand wear excellently. The second grade in softwoods and in hardwoods sufficiently limits knots and surface characteristics to assure good wearing qualities. Third Finish grade and first grade boards limit the size and character of knots, although not the number, and are satisfactory where maximum uniformity of wear is not required.

Decay-Resistance Factor

Any natural resistance to decay that a wood may have is in the heartwood. The decay resistance of the species so far as affected by grade therefore depends upon the proportion of heartwood in the grade. While this is true of all species, it is of practical importance only in woods with medium or highly decay-resistant heartwood.

The lower grades usually contain more heartwood than do the Select grades. If decay resistance is really needed for the purpose at hand, the first and second board grades are more decay-resistant than are the Finish grades, except in the case of the special Finish grades known as All Heart.

The full decay resistance of grades below the second grade is reduced by the presence of decay that may have existed in the tree or log before it was sawn into lumber. Under conditions conducive to decay, such original decay may spread, although some types of decay, notably peck in cypress, red heart in pine, and white pocket in Douglas-fir, are definitely known to cease functioning once the lumber is properly seasoned.

Price Factor

The spread in price between Select Finish and Utility Board grades varies considerably from time to time, depending upon supply and demand. The cost of the lower Select grades is substantially greater than the upper Board grades of softwoods. With such a difference in price it is obviously important not to buy a better grade than is needed. *Any tendency to buy the best the market offers for all uses is wasteful of both lumber and money,* for in uses such as sheathing, the lower and cheaper grades will render as long and satisfactory service as the higher priced grades.

The price spread between the combined grade of first and second Finish grades and the Common grades of hardwoods is also large. This is of minor importance to builders because most of the hardwood purchased by them has already been manufactured into some form of finished product, such as flooring or interior trim.

Roughly the combined grade of first and second Finish may have a market value from 50 to 100 percent greater than that of the highest Common grade, and contain from 25 to 50 percent more clear-face cuttings of the sizes specified in the grading rules. If large clear-face pieces are required, they can best and possibly only be obtained from the first and second grades. But if only medium-sized or small clear-face pieces are required, they can be obtained from the Common grades.

Standard Lumber Items And Wood-based Products In Retail Yards

Lumber is sold as a number of standard general-purpose items and also as certain special-purpose items. Retail lumberyards carry all the general-purpose items and the more important of the special-purpose items. Some lumber items can be obtained only in the upper grades, and others only in the lower. Few items are made in a complete range of grades. A brief description of framing and dimension, boards and sheathing, flooring and siding, and other lumber and related items commonly carried by most retail lumberyards is given later in this section.

Many lumberyards carry stock items in wood species besides those common to the United States. Larger lumber companies may also have their own sash and door plants and can make to order any wood unit listed in the plans or specifications of frame buildings. The popularity of

the wood truss has also brought about the fabrication of these items at many lumberyards.

Dressed Thicknesses and Widths of Lumber

Lumber as ordinarily stocked in retail yards is surfaced (dressed) on two sides and two edges. This is to make the lumber ready to use and uniform in size without further reworking, and also to avoid paying transportation costs on material that would have to be cut off on the job. The amount that is reasonable and desirable to dress off has varied considerably in the past and has been the subject of some controversy and misunderstanding among producing and consuming groups. American lumber standards have been set up by the lumber trade with the assistance of Government agencies in such a way as to largely take care of the situation.

American lumber standards and common trade practices now provide dressed sizes as summarized in tables 2 and 3 which are taken from the American Softwood Lumber Standard Voluntary Product Standard PS 20-70. The column designated nominal size shows the dimensions according to which lumber is usually described; the last column shows the actual dimensions of lumber when it is sold surfaced.

TABLE 2.—*Nominal and minimum-dressed sizes of boards, dimension, and timbers*

(The thicknesses apply to all widths and all widths to all thicknesses)

ITEM	THICKNESSES			FACE WIDTHS		
	NOMINAL	Minimum Dressed		NOMINAL	Minimum Dressed	
		Dry[1]	Green[1]		Dry[1]	Green[1]
		Inches	*Inches*		*Inches*	*Inches*
Boards[2]				2	1½	1 9/16
				3	2½	2 9/16
				4	3½	3 9/16
				5	4½	4⅝
	1	¾	25/32	6	5½	5⅝
				7	6½	6⅝
	1¼	1	1 1/32	8	7¼	7½
				9	8¼	8½
	1½	1¼	1 9/32	10	9¼	9½
				11	10¼	10½
				12	11¼	11½
				14	13¼	13½
				16	15¼	15½
Dimension				2	1½	1 9/16
				3	2½	2 9/16
				4	3½	3 9/16
	2	1½	1 9/16	5	4½	4⅝
	2½	2	2 1/16	6	5½	5⅝
	3	2½	2 9/16	8	7¼	7½
	3½	3	3 1/16	10	9¼	9½
				12	11¼	11½
				14	13¼	13½
				16	15¼	15½
Dimension				2	1½	1 9/16
				3	2½	2 9/16
				4	3½	3 9/16
				5	4½	4⅝
	4	3½	3 9/16	6	5½	5⅝
	4½	4	4 1/16	8	7¼	7½
				10	9¼	9½
				12	11¼	11½
				14		13½
				16		15½
Timbers	5 & Thicker		½ Off	5 & Wider		½ Off

[1] "Dry" lumber has been dried to 19 percent moisture content or less; "green" lumber has a moisture content of more than 19 percent.

[2] Boards less than the minimum thickness for 1 inch nominal but ⅝ inch or greater thickness dry (11/16 inch green) may be regarded as American Standard Lumber, but such boards shall be marked to show the size and condition of seasoning at the time of dressing. They shall also be distinguished from 1-inch boards on invoices and certificates.

When the dimensions of dressed lumber are less than those shown in the table for the actual sizes enumerated, the lumber is known as substandard. Items of some woods are commonly sold in substandard sizes. It is well to check the dimensions before selecting a wood so that allowance can be made in both price and utility for substandard sizes or proper credit given for oversizes.

TABLE 3.—*Nominal and minimum dressed dry sizes of finish, flooring, ceiling, partition, and stepping at 19 percent maximum moisture content*

(The thicknesses apply to all widths and all widths to all thicknesses except as modified)

ITEM	THICKNESSES		FACE WIDTHS	
	NOMINAL[1]	Minimum Dressed	NOMINAL	Minimum Dressed
		Inches		*Inches*
Finish	3/8	5/16	2	1½
	½	7/16	3	2½
	5/8	9/16	4	3½
	¾	5/8	5	4½
	1	¾	6	5½
	1¼	1	7	6½
	1½	1¼	8	7¼
	1¾	1⅜	9	8¼
	2	1½	10	9¼
	2½	2	11	10¼
	3	2½	12	11¼
	3½	3	14	13¼
	4	3½	16	15¼
Flooring[2]	3/8	5/16	2	1⅛
	½	7/16	3	2⅛
	5/8	9/16	4	3⅛
	1	¾	5	4⅛
	1¼	1	6	5⅛
	1½	1¼		
Ceiling[2]	3/8	5/16	3	2⅛
	½	7/16	4	3⅛
	5/8	9/16	5	4⅛
	¾	11/16	6	5⅛
Partition[2]	1	23/32	3	2⅛
			4	3⅛
			5	4⅛
			6	5⅛
Stepping[2]	1	¾	8	7¼
	1¼	1	10	9¼
	1½	1¼	12	11¼
	2	1½		

[1] For nominal thicknesses under 1 inch, the board measure count is based on the nominal surface dimensions (width by length). With the exception of nominal thicknesses under 1 inch, the nominal thicknesses and widths in this table are the same as the board measure or count sizes.

[2] In tongued-and-grooved flooring and in tongued-and-grooved and shiplapped ceiling of 5/16-inch, 7/16-inch, and 9/16-inch dressed thicknesses, the tongue or lap shall be 3/16 inch wide, with the over-all widths 3/16 inch wider than the face widths shown in the table above. In all other worked lumber of dressed thicknesses of ⅝ inch to 1¼ inches, the tongue shall be ¼ inch wide or wider in tongued-and-grooved lumber, and the lap of ⅜ inch wide or wider in shiplapped lumber, and the over-all widths shall be not less than the dressed face widths shown in the above table plus the width of the tongue or lap.

Framing and Dimension

Dimension is primarily framing lumber, such as joists, rafters, and wall studs. It also comprises the planking used for heavy barn floors. Strength, stiffness, and uniformity of size are essential requirements. Framing or Dimension lumber is stocked in all lumberyards but often in only one or two of the general-purpose construction woods—Douglas-fir, southern yellow pine, white fir, hemlock, or spruce. It is usually a nominal 2 inches thick, dressed one or two sides to 1½ inches dry (table 2). It is nominally 4, 6, 8, 10, or 12 inches in width, and 8 to 20 feet long in multiples of 2 feet. Dimension thicker than 2 (up to 5) inches and longer than 20 feet is manufactured only in comparatively small quantities.

Perhaps the one most suitable grade for permanent construction wall framing, based on economy and performance, is the third grade in the various species. The grade most generally suitable for joists and rafters for permanent and first-class construction is the second grade of the various species. Satisfactory construction is possible with lower grades, but pieces must be selected and there is considerably more cutting loss. Many species have structural grade classifications that may be used for trusses and other structural components. These structural grades allow greater loads than do equal spans of the lower grades.

Boards or Sheathing

Boards are a general-purpose item used most often to cover framing members as flooring, roofing, and wall sheathing. They are available at all lumberyards in one or more kinds of wood most frequently used in building construction. Boards are usually of nominal 1-inch thickness, dressed on two sides to ¾-inch dry thickness, and are usually manufactured in all grades from first to fifth (table 3). However, as sheathing material, the third and fourth grades are most often used.

Boards or sheathing are manufactured in a number of patterns. They may be square-edged (surfaced on four sides), generally supplied in nominal 4-, 6-, and 8-inch widths. They are also available in dressed and matched pattern (tongued-and-grooved) and in shiplap (fig. 6). Dressed and matched material is most commonly sold in 6-inch widths, and shiplap in 8-, 10-, and 12-inch widths. In addition to sheathing and subflooring, boards are used for rough siding, barn boards, and concrete forms. The advent of the pole-type construction has developed the need

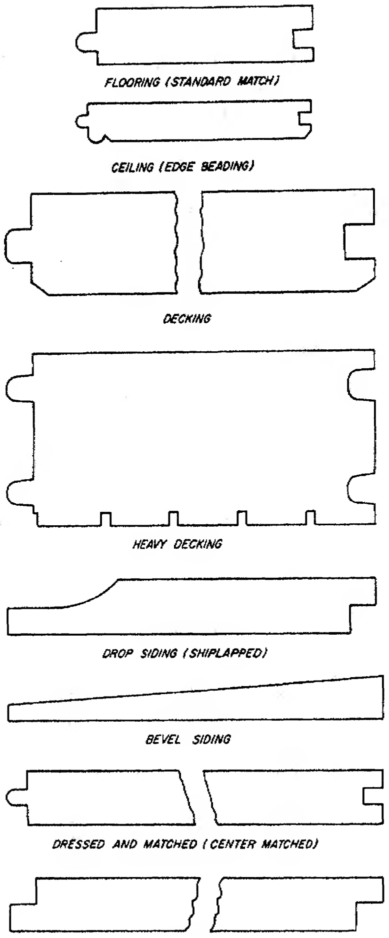

FIGURE 6.—Typical patterns of lumber.

for center-matched sheathing in 2- by 6-inch nominal size. Many lumber companies stock this item preservative-treated.

Siding

Siding, as the name implies, is made and generally used for exterior coverage. It is produced in several general patterns: bevel siding, drop siding, and V-edge siding or paneling (fig. 6). Bevel siding is ordinarily stocked in Clear, A grades and B grades of redwood, western red cedar, hemlock, white and ponderosa pine, and spruce. Drop siding is stocked in C and Better and No. 2 Common grades, and V-edge paneling in Clear, and C and Better. Additional species used for drop and V-edge siding are Douglas-fir and southern pine.

Other exterior lumber coverings include "boards and battens" and other combinations for vertical application. These are commonly rough-sawn boards in Finish grades that are given a stain finish.

Bevel siding (fig. 6) is commonly supplied in $\frac{1}{2}$-, $\frac{5}{8}$-, and $\frac{3}{4}$-inch thicknesses in nominal 6-, 8-, and 10-inch widths. Special patterns are available in 12-inch widths. Drop siding is normally $\frac{3}{4}$ inch in thickness and $5\frac{1}{4}$ inches in face width. (Face width is the coverage width when material is in place.) V-edge siding is $\frac{3}{4}$ inch thick and 6, 8, and 10 inches nominal width (fig. 6). Bevel siding ordinarily is not used for barns, garages, and similar buildings because of cost. Also it is normally laid horizontally over lumber, plywood, or other wood-base sheathing. Some of the thicker grades are occasionally used without sheathing on small garages when the studs are spaced no more than 16 inches on center. Bevel siding is lapped from 1 to $1\frac{1}{2}$ inches depending on spacing required between window heights.

Drop siding (fig. 6), because of its uniform thickness, is most often used without sheathing and is applied horizontally. Drop siding has a $\frac{3}{8}$- to $\frac{1}{2}$-inch lap. Matched pattern drop siding is also available. V-edge dressed and matched siding may be applied horizontally or vertically. When it is applied vertically, blocking is required between the studs or vertical members to provide for nailing, if sheathing is not of plywood or lumber. Board and batten combinations require the same type of backing.

The lap of the bevel siding, combined with the actual width, makes it necessary to use from 120 to 150 surface feet for every 100 square feet of surface to be covered. Drop siding requires somewhat less than 115 board feet of 1- by 6-inch drop siding to cover 100 square feet of surface, discounting cutting loss.

Other siding materials that are available in many lumberyards include paper-overlaid plywood siding, and medium- and high-density hardboard. These materials can usually be obtained in 4-foot-wide sheets or prepackaged in narrow sections ready for installation. Medium- or high-density overlaid plywood sheets in $\frac{1}{2}$-inch and greater thicknesses can be applied vertically directly on framing members with proper spacing, serving both as sheathing and siding, for barns and other buildings. Batten strips are normally used over the vertical joints.

Flooring

Flooring (fig. 6) is made chiefly of hardwood such as maple, oak, birch, and beech, and of the harder softwood species such as Douglas-fir and southern pine. At least one of the softwoods and two of the hardwoods are stocked in most lumberyards. Flooring is usually of nominal 1- by 3- and 1- by 4-inch sizes. Dressed thickness is $\frac{25}{32}$ inch, and face widths are $2\frac{1}{4}$ and $3\frac{1}{4}$ inches. Thicker flooring, in Douglas-fir and southern pine, is available and is used for porch flooring without need for a subfloor. Edge grain proves

the most satisfactory. Thinner hardwood flooring, usually square-edged, is another form sometimes used as a finish floor.

Block or parquet flooring in 3- or 5-ply plywood or laminated form is available in ½- and ²⁵⁄₃₂-inch thicknesses, and is also made in particleboard form. Block flooring is usually installed with a mastic adhesive. When placed on concrete floors, a sealer is used under the block floor and a vapor barrier under the concrete slab to prevent moisture problems.

Edge-grained flooring shrinks less in width than flat-grained flooring, is more uniform in texture, wears more uniformly, and joints do not open up as much. Flat-grained flooring costs less and is commonly used where appearance is not important. Both edge- and flat-grained flooring are carried in stock by many dealers.

Most softwood flooring is either southern yellow pine or Douglas-fir. The higher grades are commonly finished with varnish or sealer. The lower grades are perhaps most suited for dark-stained or painted finishes. Southern pine has five grades: A, B, C, D, and No. 2 flooring; A and B grades are often combined and are classed as B and Better. Douglas-fir has edge- and flat-grained classifications: edge grain in B and Better, C, and D grades, and flat grain in C and Better, D, and E grades.

Hardwood unfinished flooring has many grade classifications depending on the species. Oak flooring has edge-grained grades classed as Clear and Select. Flat-grained oak flooring can be obtained in grades of Clear, Select, No. 1 Common, and No. 2 Common. Maple, birch, and other species have classifications of First, Second, and Third grades.

Exterior Molding and Finish

Exterior moldings and finish are used on cornices, at gable ends, and other finish areas of buildings. Houses may ordinarily be designed with a closed cornice for a desired architectural appearance, but sheds, barns, and other buildings are usually constructed with an open cornice or rafter overhang. Exterior moldings are usually furnished in clear ponderosa pine, southern yellow pine, and Douglas-fir. Many types and sizes are available including crown molding, brick molding, and bed molding as well as moldings used for door and window trim.

Exterior finish material is furnished in the Select grades in nominal sizes from 1 by 2 to 1 by 12 inches and also in 1¼ by 6 and 1¼ by 8 inches, all surfaced four sides (S4S). The nominal 1-inch finish is used for cornice construction and the 1¼ inch at gable ends or other areas where siding terminates. Woods used include ponderosa pine, western red cedar, redwood, and west coast hemlock.

Shingles

Most wood shingles available in retail lumberyards are of western red cedar, although redwood, white cedar, and cypress are also sometimes stocked. Three grades of shingles are classed under Red Cedar Shingle Bureau rules in three lengths:

No. 1 Blue Label shingles are all clear, all heart, and all edge grain, and are used for the best work as they are less likely to warp. No. 2 Red Label shingles have clear butts about two-thirds to three-quarters of their length and may contain some flat grain and a little sapwood. This grade is often used for roofs of secondary buildings or to cover sidewalls.

No. 3 Black Label shingles have knots and other defects that are undesirable for surface exposure, but have a 6- to 10-inch clear butt depending on their length. This grade is sometimes used as the undercourse in double-course application of sidewalls. An undercoursing shingle is produced expressly for use on double-course sidewalls.

Shingles are produced in three lengths—16, 18, and 24 inches. The 16-inch shingle, the one most likely to be stocked by retail lumberyards, has a standard thickness designated as 5/2-16 (five shingles measure 2 inches thick at the butt when green). The 16-inch shingles are based on a 5-inch exposure when used on roofs, and four bundles will cover 100 square feet (one square). When used in single-course sidewall application, three bundles of 16-inch shingles will cover 100 square feet laid with a 7-inch exposure. Bundled shingles come in random widths of 3 inches and up. Five 18-inch shingles measure 2¼ inches at the butt, and four 24-inch shingles measure 2 inches at the butt when green.

Door and Window Frames

Wood door and window frames, sash, and other similar millwork items are sometimes available in retail lumberyards in standard sizes. Sash and door manufacturers produce ready-hung window units, and the frame, weather-stripped sash, and trim are prefitted, assembled, and ready to be placed in the rough wall opening. However, in smaller retail yards it is usually necessary to order before actual use because many window and door sizes and styles are not stock items.

Ponderosa pine is a species used by most manufacturers for frames and window sash, but southern pine and Douglas-fir are sometimes used for frame parts. Frames for outside doors are usually provided with oak sills to increase their resistance to wear. However, some sills of the softer woods are supplied with metal edgings located at the wearing surfaces.

Most present-day millwork such as door and

window frames, sash, and exterior doors are treated at the factory with a water-repellent preservative. This treatment not only aids in resisting moisture but also in minimizing decay hazards.

Plywood

Because plywood is widely available, relatively low in cost, and easy to apply, it can be used to advantage in the construction of homes and farm buildings. It is principally used as a covering material such as subfloor, wall sheathing, and roof sheathing. It is often used for walls and roofs without additional covering for secondary farm buildings. Plywood may also be used for doors of barns and other buildings, and interior lining of barns and milking parlors. It may be used for cabinetwork and as an interior finish wall panel material fabricated in many forms from a variety of species.

The two common types are Interior and Exterior, and these names designate their recommended uses. Sheathing grades are also available. One form of plywood has a resin-impregnated paper overlay on two sides; in this form it is sometimes used as an exterior siding or finish without the benefit of sheathing. This type of plywood is made with waterproof glue and consequently is suitable for exterior use.

Information and other data for softwood plywoods are covered in Product Standard 1-66 Softwood plywood, construction and industrial. Information can also be obtained from the American Plywood Association.

Both Exterior and Interior types are available with a variety of sizes and grades of face veneers, ranging from A-A and paper-overlaid faces to C-D sheathing grade. The following are general thicknesses and grades commonly used in frame construction:

Plywood in the Standard interior grade commonly used for wall sheathing should be 3/8 or 1/2 inch thick if a siding is applied over the plywood. Rough-textured or patterned exterior plywood (stained finish) used as exterior finish without sheathing is usually 1/2 inch or more thick depending on the spacing of the studs and the species of plywood. Plywood roof sheathing (Standard interior, C-D) should be at least 3/8 inch thick if Douglas-fir or southern pine plywood is used and rafters are spaced 16 inches on center. When rafters are spaced 24 inches on center, plywood sheathing should be at least 1/2 inch thick if Douglas-fir or southern pine is used, and 5/8 inch thick if other western softwoods are used.

Douglas-fir or southern pine plywood used as subflooring should be at least 1/2 inch thick and other softwood plywood 5/8 inch thick when strip flooring is employed. When wood block finish floor is specified for houses, plywood should be 5/8 inch thick. For a resilient finish floor, the plywood should be 3/4 inch thick. In floors for sheds and barns, plywood can be 5/8 or 3/4 inch thick depending on the spacing of the joists. Side- and end-matched Douglas-fir plywood in 1 1/8-inch thickness is available for use when supports are spaced as much as 48 inches on center. Plywood used for subfloor and for wall and roof sheathing may be Interior or Exterior. For exterior use, plywood should always be Exterior type.

Hardwood plywood is available in a number of species; perhaps its main use is as a finish covering. The three types available include: Type 1, fully waterproof bond; type 2, water-resistant bond; and type 3, moisture-resistant bond. Details are outlined in U.S. Commercial Standard CS 35. Grades consist of Premium; Good, which is suitable for natural finish; Sound, suitable for a smooth painted surface; Utility, which might be used as sheathing or similar coverages; and Backing. Knots, splits, and other defects are allowed in the Utility and Backing grades.

Much hardwood plywood is used as veneers for flush-solid and hollow-core doors. Because of its variety of uses, standard hardwood plywood is available in widths of 24 to 48 inches and lengths from 48 to 96 inches.

Other Sheet Materials

STRUCTURAL INSULATING BOARD

Many types of sheet materials in addition to plywood are being used for sheathing walls because they are easily applied and resist racking. Structural insulating board sheathing in 1/2- and 25/32-inch thicknesses is available in 2- by 8-foot and 4- by 8-foot sheets. The 2- by 8-foot sheets are applied horizontally and usually have shallow V or tongued-and-grooved edges. The 4- by 8-foot sheets are square-edged and applied vertically with perimeter nailing. These building boards are made water resistant by means of an asphalt coating or by impregnation.

When insulating board sheathing is applied with the 2- by 8-foot sheets horizontally, the construction normally is not rigid enough. Auxiliary bracing, such as 1- by 4-inch let-in bracing, is necessary.

A wall with enough rigidity to withstand wind forces can be built with 4- by 8-foot panels of three types—regular density sheathing 25/32 inch thick, intermediate density material 1/2 inch thick, or nail-base grades. Panels must be installed vertically and properly nailed. Each manufacturer of insulating board has recommended nailing schedules to satisfy this requirement.

Interior structural insulating board 1/2 inch thick and laminated paperboard in 1/2- and 3/8-inch thickness may be obtained in 4- by 8-foot sheets painted on one side, or in paneled form

for use as an interior covering material. These materials are also produced in a tongued-and-grooved ceiling tile in sizes from 12 by 12 inches to 16 by 32 inches; thicknesses vary between ½ and 1 inch. They may be designed to serve as a prefinished decorative insulating tile or to provide acoustical qualities. The present practice of manufacturers is to furnish interior board either plain or acoustical with a flamespread-retardant paint finish.

MEDIUM HARDBOARD

Medium hardboards are generally available in nominal 7/16- and ½-inch thicknesses in 4-foot-wide sheets or in the form of siding. This material provides good service when used as exterior coverage in sheet form or as lap siding. The 4- by 8-foot sheets are applied vertically, with batten strips placed over the joints and between for decorative effect.

HIGH-DENSITY HARDBOARD

High-density hardboard in standard or tempered form is commonly supplied in ⅛- and ¼-inch-thick sheets of 4- by 8-foot size. It may be used for both interior and exterior covering material. As with plywood or medium hardboard, the high-density hardboard in the thicker types can be applied vertically with batten strips, or horizontally as a lap siding.

It is often used in the construction of barn doors and for interior lining of barns and other buildings. In perforated form, both types of hardboard are used as soffit material under cornice overhangs to ventilate attic spaces. In untreated form, high-density hardboard of special grade is also used as an underlayment for resilient flooring materials. Hardboards can be obtained with decorative laminated surfaces that provide a pleasing appearance as interior paneling.

PARTICLEBOARD

Particleboard, a sheet material made up of resin-bonded wood particles, is most often used as an underlayment for resilient flooring. It is also adaptable as covering material for interior walls or other uses where they are not exposed to moisture. Particleboard is usually supplied in 4- by 8-foot sheets and in ⅜-inch thickness for paneling, in ⅝-inch thickness for underlayment, and in block form for flooring. It is also used for cabinet and closet doors and as core stock for table tops and other furniture.

Interior Finish and Millwork

Interior finish and millwork include doorjambs and doors; casing, base, base shoe, stool, apron, and other trim and moldings; stair parts; and various cabinets, fireplace mantels, and other manufactured units. Such interior trim as casing and base is stocked in most retail lumberyards in several patterns and at least one species of wood.

Ponderosa pine, Douglas-fir, and southern yellow pine are the softwoods usually available. Oak and birch are hardwoods most likely to be stocked by lumberyards. Species not carried in stock may be obtained and manufactured on special order. Interior trim, moldings, and other interior finish are ordinarily furnished in a clear grade. Paneling in pine, cedar, and similar woods usually contains knots and other grain variations for a decorative effect.

Inside doorjambs are ¾ inch thick and vary in width from 4½ to 5⅜ inches, depending on the type of interior wall finish—drywall or plaster. Base may vary in size from 7/16 by 2¼ inches to 9/16 by 3¼ inches and wider. The modern trend is toward a narrow base, except in strictly traditional interiors. Base shoe is ½ by ¾ inch in size, although quarterround, ¾ by ¾ inch, is sometimes used as a molding between the base and the finish floor.

Casing and other trim around door and window frames may be obtained in several patterns and sizes. Two common patterns are the "Colonial" type with a molded face and "Ranch" or "Bevel" trim with a simple beveled face and rounded corners. These types of casing are usually ⅝ or ¾ inch thick and 2¼ to 2¾ inches wide.

Cabinets, fireplace mantels, and stair parts are usually special-order items that the lumber dealer must order from the manufacturer. Interior doors in flush or panel type are often stocked in standard sizes by many of the larger retail yards.

Interior doors are normally 1⅜ inches thick and vary in width from 2 feet for small closets, to 2 feet 6 inches and wider for other doors. Standard height is 6 feet 8 inches for doors used on the first floor and 6 feet 6 inches for doors used on the second floor. There is a trend in some interior designs of houses to use full wall-height doors. This eliminates the need for headers, head casing and trim, and other construction details associated with lower doors.

Standard exterior doors are 1¾ inches thick and 6 feet 8 inches high. Panel doors with solid wood rail and stiles, and solid-core flush doors are the types most often stocked in retail lumberyards for exterior use.

Wood has withstood the test of time as a building material. On every hand one can see homes and other buildings which prove the permanence of proper wood construction (fig. 7). Good construction practices for all important structural parts of houses are shown in Agriculture Handbook No. 73, "Wood-Frame House Construction," mentioned on page 2.

Defects that show up in buildings are frequently wrongly ascribed to the type of material used, when they are actually often due to the condition of the material when installed, or to the design, construction, or maintenance of the building. When problems arise, all these factors should be reviewed as possible causes.

Perhaps more unsatisfactory service has resulted from the common failure to use wood at the proper moisture content than from any other cause. The next few pages will outline recommendations for the proper moisture content of wood used in construction. Defects caused by Framing and Finish lumber that is not at the proper moisture content are often difficult or costly to correct.

After the house has been constructed with dry lumber, it is important that the materials remain dry in service. Proper construction details and good carpentry are necessary to assure that moisture does not enter the walls or the interior of the house, for example, proper flashing and clearances (fig. 8). Excessive changes in its moisture content induce swelling and shrinkage of wood, and are often responsible for plaster cracks and other inconveniences.

How Dry Should Wood Be When Installed?

The installation of wood at the proper dryness means practically no serious shrinkage later. Wood at the time of installation should be seasoned to about the average moisture content that it will have in service. The moisture content of interior trim at the time of installation should be between 5 and 10 percent in most parts of the United States.

In the southern coastal regions, where the humidity is high, the moisture content should be between 8 and 13 percent; for the dry south-

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FIGURE 7.—Wood has served in fine homes of the past and promises equal service in the homes of the future. More than a century ago this home of Ralph Waldo Emerson was built of wood. Well planned and built, and well maintained, it has served down through the years and is still an attractive, serviceable structure.

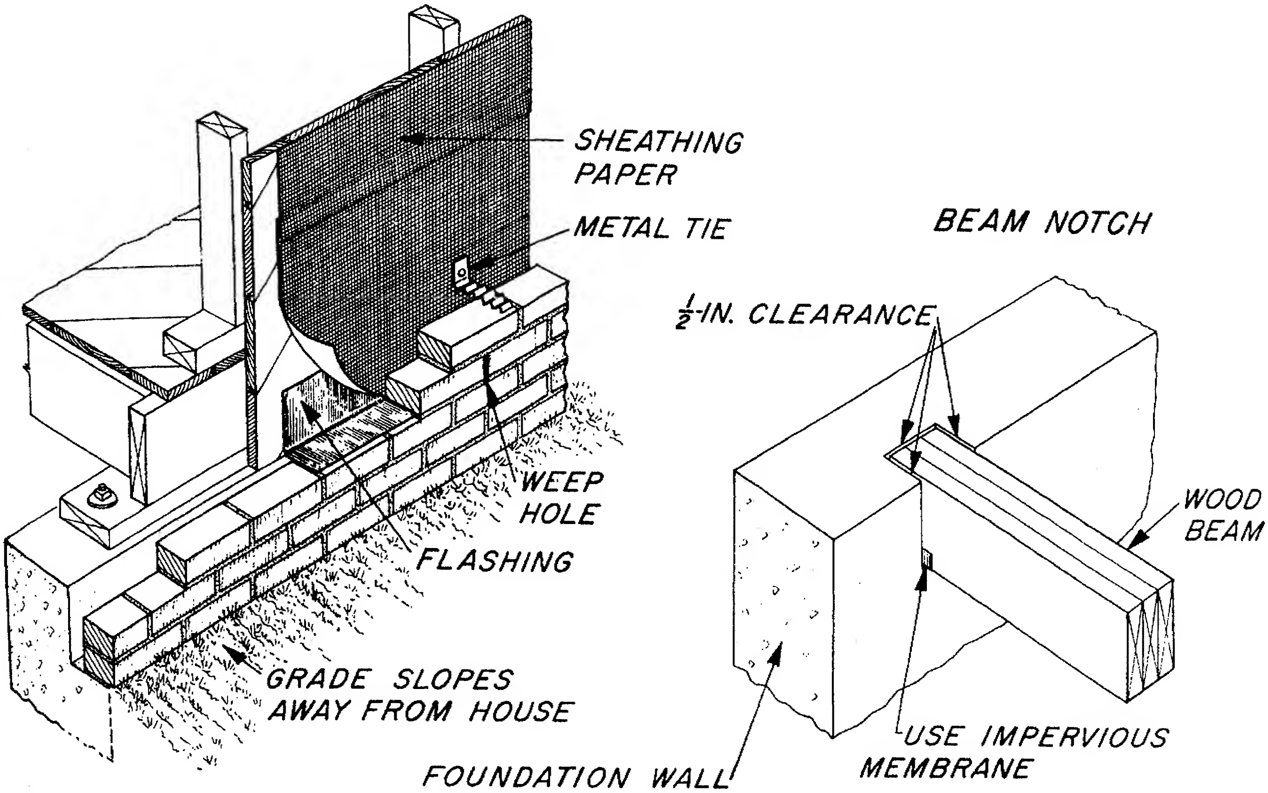

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FIGURE 8.—Proper flashing of masonry veneer and beam notch detail assures that the wood is kept dry.

western region, where the humidity is low, the moisture content should be between 4 and 9 percent.

The moisture content of sheathing, framing, siding, and exterior trim at the time of installation should be between 9 and 14 percent in most parts of the United States, and between 7 and 12 percent in the dry southwestern regions.

Determining Moisture Content of Wood

It is very difficult to tell how dry a piece of wood is by looking at it or feeling it. How then can a determination be made? Two means of measurements are available—by use of an electric moisture meter or by the ovendrying method. In addition, there is one way of getting an approximation.

The moisture meter is simple and fast to use and permits determination of moisture content without cutting the board. Several models are available. When used on wood with a moisture content below about 30 percent, these meters can be quite accurate.

The most accurate method of determining moisture content is by ovendrying specimens—a standard method by which degree of dryness is expressed for technical and commercial purposes. The procedure involves cutting small sections and weighing them; these sections are dried to constant weight in an oven, reweighed, and the moisture content computed. This method is accurate through the whole range of moisture content. Because of the equipment and time involved, it is used mainly where very exact moisture determinations are necessary.

A rough approximation of moisture content can be made at home by the following procedure:

Select several flat-grained boards from the lumber and cut a sample from each. The sample should measure 1 inch along the grain and be cut to include the entire width of the board (at least 6 inches). It should be cut about 6 to 8 inches from the end of the board. Trim the sample so that it will measure exactly 6 inches in width and place it in a warm, dry place—near the furnace, on a heat duct, on a radiator, or in the oven—and leave it 48 hours or until it ceases to shrink; then measure the 6-inch dimension to determine how much it has shrunk.

If the wood is classed C in freedom from shrinkage (table 1, column 4), it should not shrink more than ⅛ inch if it is to be used for

interior trim or finish, nor over twice that amount (1/4 inch) if it is to be used for framing, coverage, or where it is exposed to the weather.

Woods classed as B in freedom from shrinkage (table 1, column 4) should not shrink over 3/32 inch, and Class A woods not over 1/16 inch if they are to be used for interior trim, finish, or floors. If they are to be used exposed to the weather, B woods should not shrink more than 3/16 inch, or A woods 1/8 inch. For lumber under 6 inches wide use 3-inch samples. The shrinkage limits should be half those listed for 6-inch samples.

Edge-grained lumber shrinks only about one-half as much as flat-grained. If it is not possible to obtain a flat-grained sample, an edge-grained sample may be used, but the shrinkage should not be over half that shown for flat grain. It is best not to use edge-grained samples or samples shorter than 6 inches; not only are they more difficult to measure, but they do not give so reliable an indication of the adequacy of seasoning.

Keeping Lumber Dry in Service

Dry wood takes up moisture not only from actual contact with water but from other sources commonly overlooked. It may collect moisture in the form of vapor from damp air or from damp plaster, concrete, soil, or brickwork. Like many other building materials, wood will absorb moisture that has condensed on it, as well as rain or snow that has entered joints and crevices.

The protection of wood from moisture usually requires that it be kept from contact with soil and water; that free circulation of air be provided in damp areas; and that exposed surfaces be protected with paint, varnish, or other coatings. Protective coatings reduce but do not entirely prevent moisture absorption, and therefore should not be relied upon to compensate for poor drainage and poor ventilation. Decay hazards as associated with the moisture content of wood in use are discussed in a later section (see p. 38).

Avoiding contact of wood with moisture is of prime importance in considering construction details. Special care must be used at the grade line of a structure or at any point where moisture might come in. Protection from moisture in the ground should be provided even in temporary or portable buildings.

A little additional care at the start in selection of material and construction details will eliminate the later need for frequent replacement of skids, sills, and framing members (fig. 9). The use of treated wood sills or placing the structure on masonry blocking for good air circulation is good practice. A ground cover will minimize movement of water vapor from the ground and prevent the wood from retaining high levels of moisture content. Vapor barriers such as polyethylene, roll roofing, or duplex asphalt papers are satisfactory.

Clearance of wood parts above the finish grade and drainage of water away from the building by means of a splash block or tiling are also important factors (fig. 10). It is difficult to miter siding at corners to prevent moisture entry, especially in the wider patterns. Generally, it is better practice to use corner boards or metal corners. Plant growth against the siding or other wood members should be removed as it encourages moisture retention and possible decay. Downspouts and other attachments should be clear of the siding.

Proper use of vapor barriers in walls and ceilings, in crawl spaces, and under concrete slabs will prevent wood from becoming wet and a possible decay hazard.

Correct construction details at window and door frames to prevent rain leakage and reduce

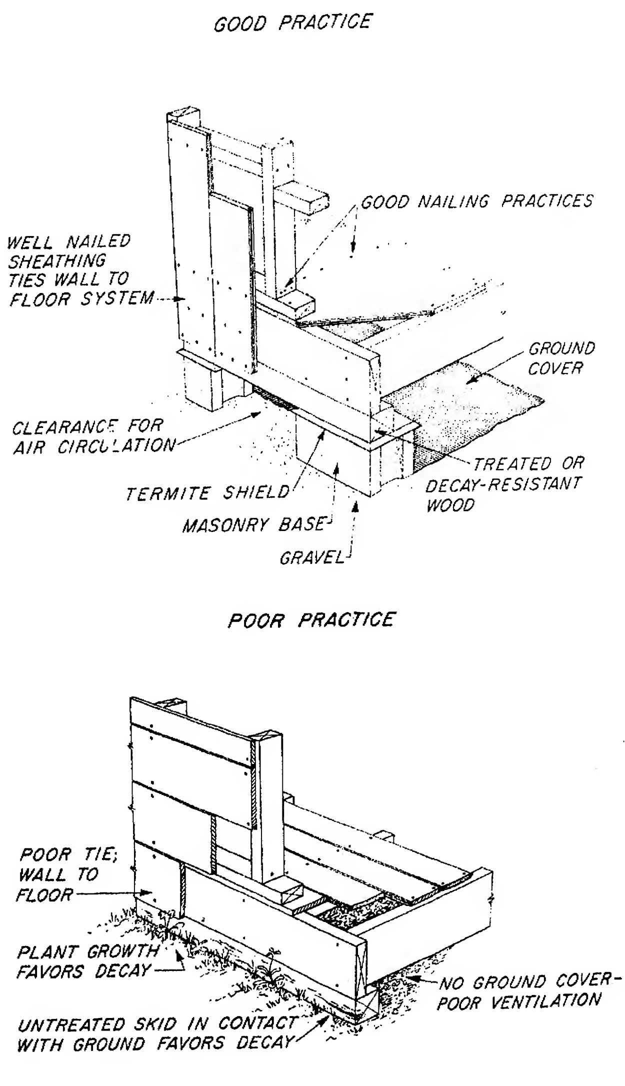

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FIGURE 9.—Good and poor practice for foundations of temporary buildings.

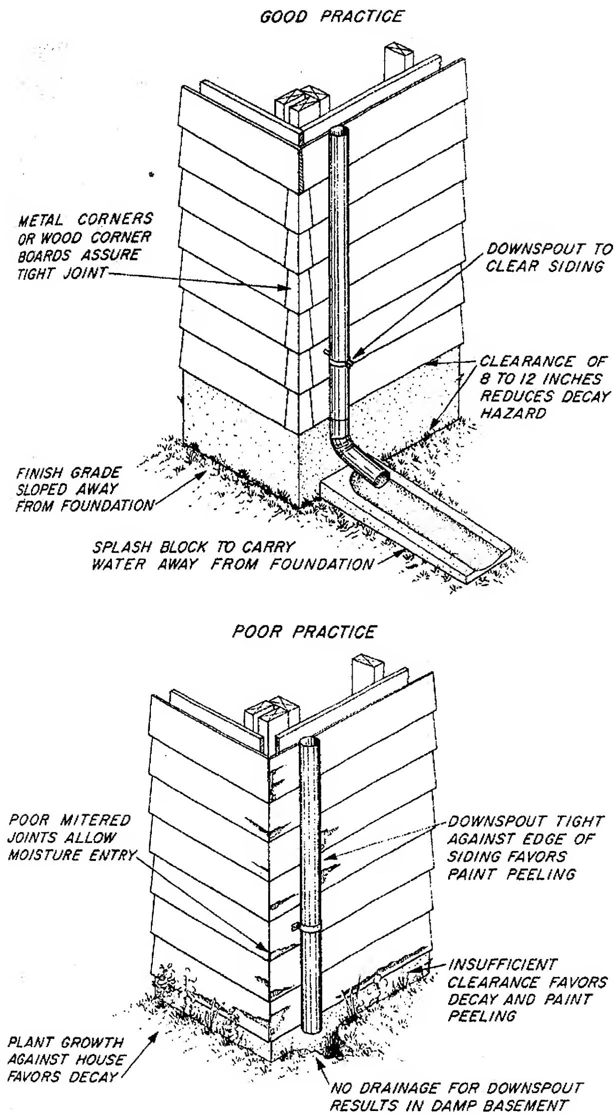

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FIGURE 10.—Good and poor practice with siding joints and downspouts.

air infiltration are important (fig. 11). Good carpentry will assure tight joints of the siding at the casing and under the sill. Proper flashing at the drip cap, and use of building paper around the framed opening will help as will weather-stripping around the sash. Frames and sash are normally treated with a water-repellent preservative at the factory and paint will provide additional protection.

The cornice and gutter details are important if hazards of poor roof drainage are to be eliminated (fig. 12). Wide cornices and good drip details eliminate many hazards. A width of roofing paper under the shingles at the cornice and good soffit ventilation, in addition to outlet ventilators, will minimize damage that is often caused by ice dams. Other details relating to moisture in wood are discussed later.

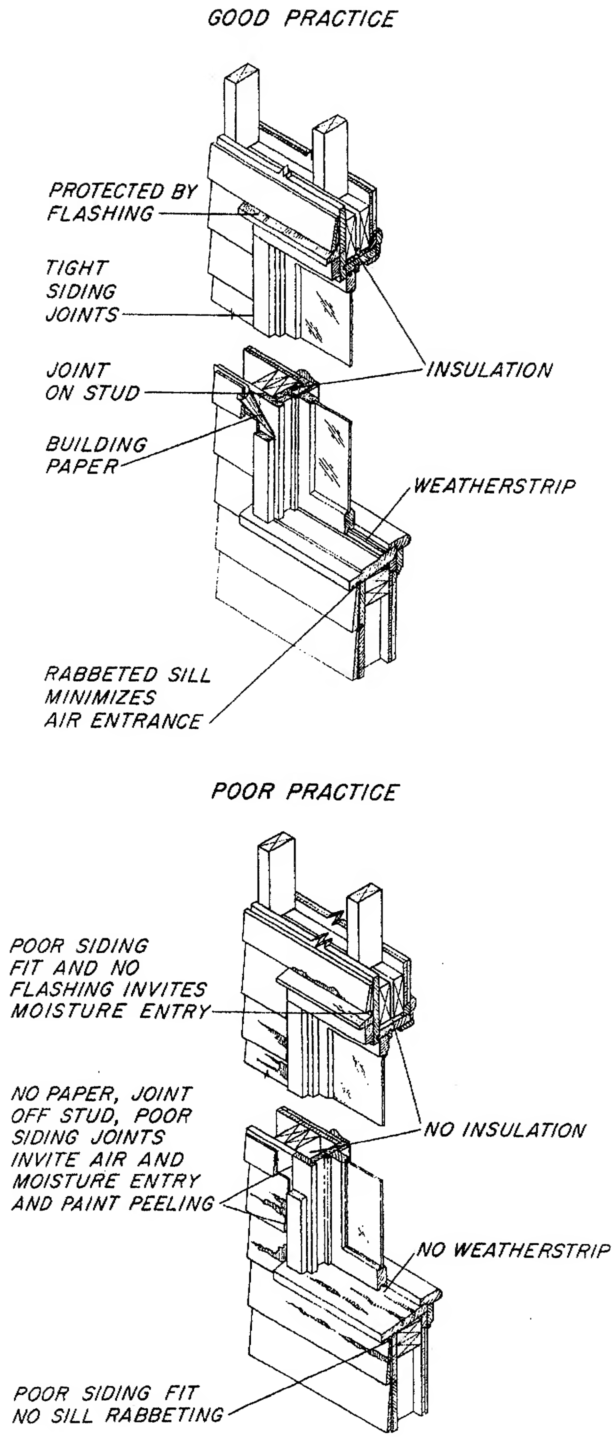

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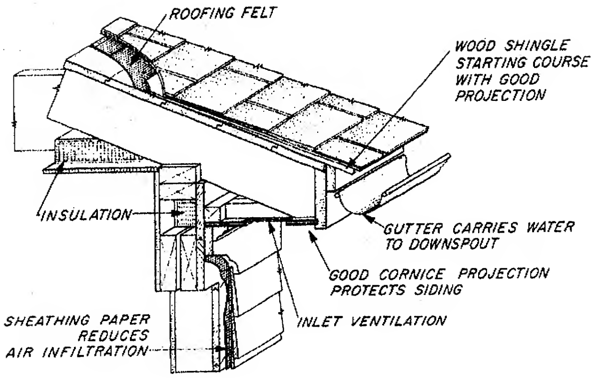
FIGURE 11.—Good and poor practices with frames.

GOOD PRACTICE



POOR PRACTICE

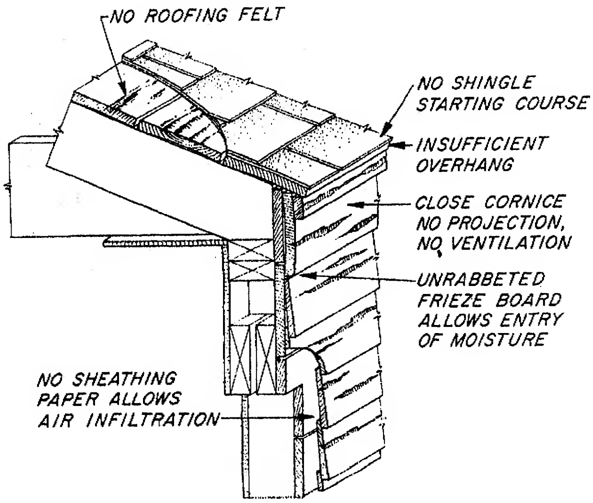


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FIGURE 12.—Good and poor practices in cornice construction.

Preventing Defects Due to Shrinkage

Although wood will shrink under certain conditions, it will give satisfactory service when the shrinkage factor is recognized and properly controlled. Problems due to shrinkage can be greatly reduced by: (1) using seasoned woods as required by conditions of use; (2) protecting by paint, water repellents, or other protective coatings all exposed surfaces of dry wood in place so that rapid moisture changes will not occur; (3) selecting woods with low inherent shrinkage (table 1); or (4) using edge-grained material in preference to flat grain for critical uses.

Following the first two rules will insure wood that meets the ordinary requirements of construction. More exacting requirements, such as those of doors, window sash, and frames, require in addition either the selection of woods from the low- or moderate-shrinkage groups or the use of edge-grained material. Special conditions often prevent the application of all four rules. One or more of the rules, however, can always be applied, so as to enable wood to meet the requirements satisfactorily in most cases.

Preventing Decay

The simplest way to prevent wood from decaying is to keep it dry. This means protecting it from common decay hazards caused by leaks, by the contact of wood with the ground, or by contact of wood and water. It also means protecting wood from such commonly unrecognized decay hazards as are caused by small amounts of water that get into the wood and cannot get out. Water is often held in the wood by some type of covering or by lack of ventilation or drainage. Many of these unrecognized decay hazards are at joints that are exposed to the weather and at surfaces where the wood is in contact with other materials. Frequently it is cheaper and easier to change a detail of construction to keep the moisture out than to follow poor design and rely on decay-resistant wood or paint coatings.

CONSTRUCTION DETAILS

Various figures in this bulletin show good and poor practice in several important building details. Four main principles of design to prevent decay of wood members are:

1. Free drainage or good construction details where wood contacts flat areas, such as posts in contact with a concrete slab.

2. Good ventilation to prevent the accumulation of damp air in crawl spaces, under porches and steps, and around the roofing and rafters of barns. Ground covers of roll roofing, polyethylene, or other similar materials will minimize the movement of ground moisture into crawl spaces or under porches. Any enclosed space should be ventilated.

3. Protection of wood from condensation, such as occurs on cold-water pipes and on window glass, especially in dairy barns, bathrooms, kitchens, and all artificially humidified rooms. Insulating cold-water pipes reduces the relative humidity, and hanging them free of joists prevents condensation on the wood. The use of storm windows will usually minimize or eliminate condensation on the glass surfaces.

4. Protective coatings or coverings, such as roofing felt, tarred and mopped down, or polyethylene will prevent absorption from damp concrete, masonry, or earth. The use of a vapor barrier under the concrete slab will eliminate the movement or absorption of ground moisture.

Examples of poor construction practices that provide conditions favorable for decay, and ex-

amples of protective measures and good design aimed at reducing decay hazards in wood construction are illustrated in the figures that follow.

At cornices (fig. 12), good drainage will eliminate the hazards of rain entering the overhang.

Correct method of placing wood posts or columns on a concrete floor is shown in figure 13. A concrete pedestal or block to raise the bottom of the post above the floor is an important factor.

A good method of hanging cold-water pipes is illustrated in figure 14. When pipes contact the joists, condensation on the pipes during the warmer months keeps the joist wet and invites decay. Hanging these pipes free of joists avoids this problem. Covering the cold-water pipes with insulation will also help.

Good practice in the manufacture and use of window sash is shown in figure 15. Priming and back puttying are important in preventing moisture entry behind the putty. A water-repellent preservative dip will also aid in reducing moisture entry.

Examples of both good and poor construction practices in placing wood floors over concrete slabs are given in figure 16. A good vapor barrier under the concrete slab is an important factor in preventing moisture entry.

Examples of both good and poor construction practices in installing drip cap over exterior of window sash are illustrated in figure 17. Use of flashing over drip cap, and overlapping siding on drip cap help greatly to prevent entry of moisture which causes paint to peel.

Many decay hazards cannot be eliminated or modified by design or by protective coatings. The conditions of use may be such that wood must touch the ground or water. For example, there is no practical method by which wood piers to buildings, fenceposts, sills on the ground, or sleepers embedded in concrete can be kept dry. Protection against decay in such uses lies in preservative treatment. One type of use that requires treated or decay-resistant woods is shown in figure 16.

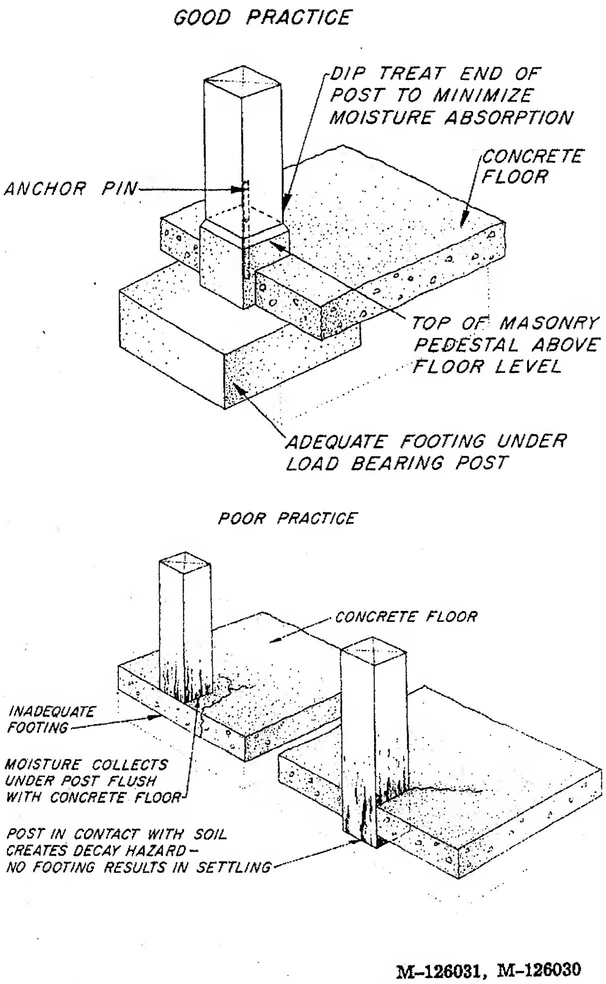

FIGURE 13.—Good and poor practice with wood posts.

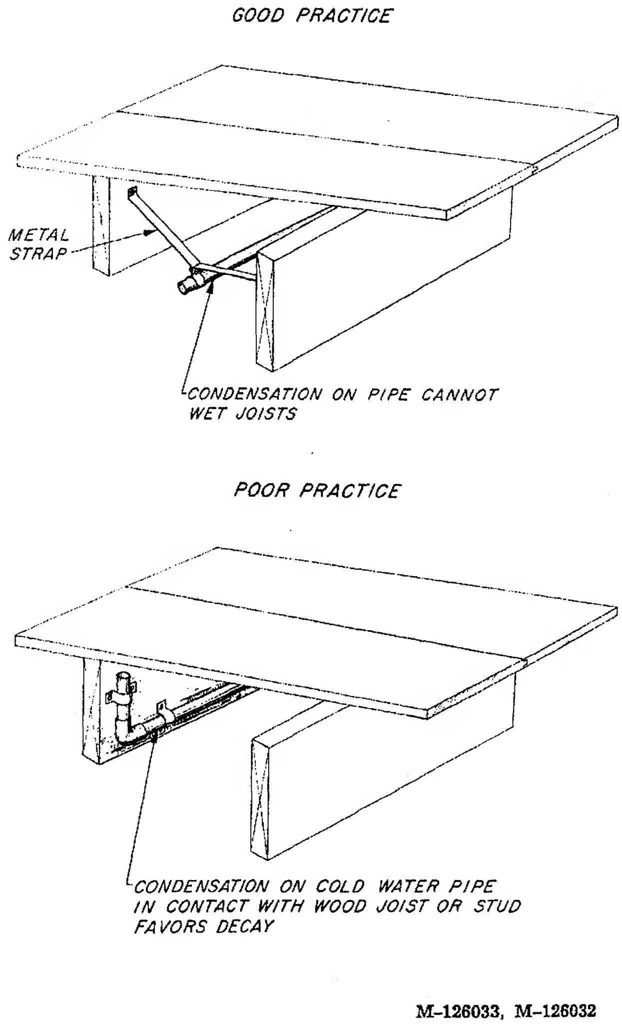

FIGURE 14.—Good and poor practice for supporting water pipes.

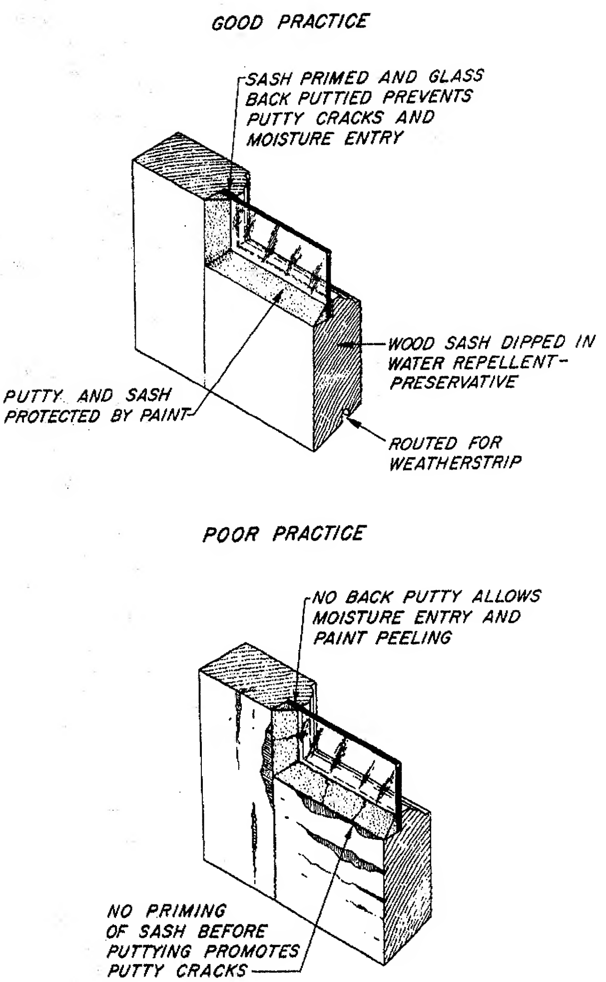

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FIGURE 15.—Good and poor practice with window glass.

PRESERVATIVE-TREATED MATERIAL

Good preservative treatment will insure longer life for wood that is not resistant to decay but must be used in contact with the ground or in a moist area. A normal life of 3 years for an untreated southern pine fencepost can be increased to 35 years or more if the post is effectively treated. Wood, when effectively treated, can be considered on the same basis as other so-called permanent materials.

Wood-preserving methods are of two general types: (1) Pressure processes in which the wood is impregnated in closed vessels under pressures considerably above atmospheric pressure; and (2) nonpressure processes including soaking, diffusion, brushing, spraying, and dipping. Pressure processes generally provide greater protection than nonpressure processes.

Preservatives for wood are also of two types: (1) Oils, such as creosote, creosote solutions, and pentachlorophenol, and copper naphthenate

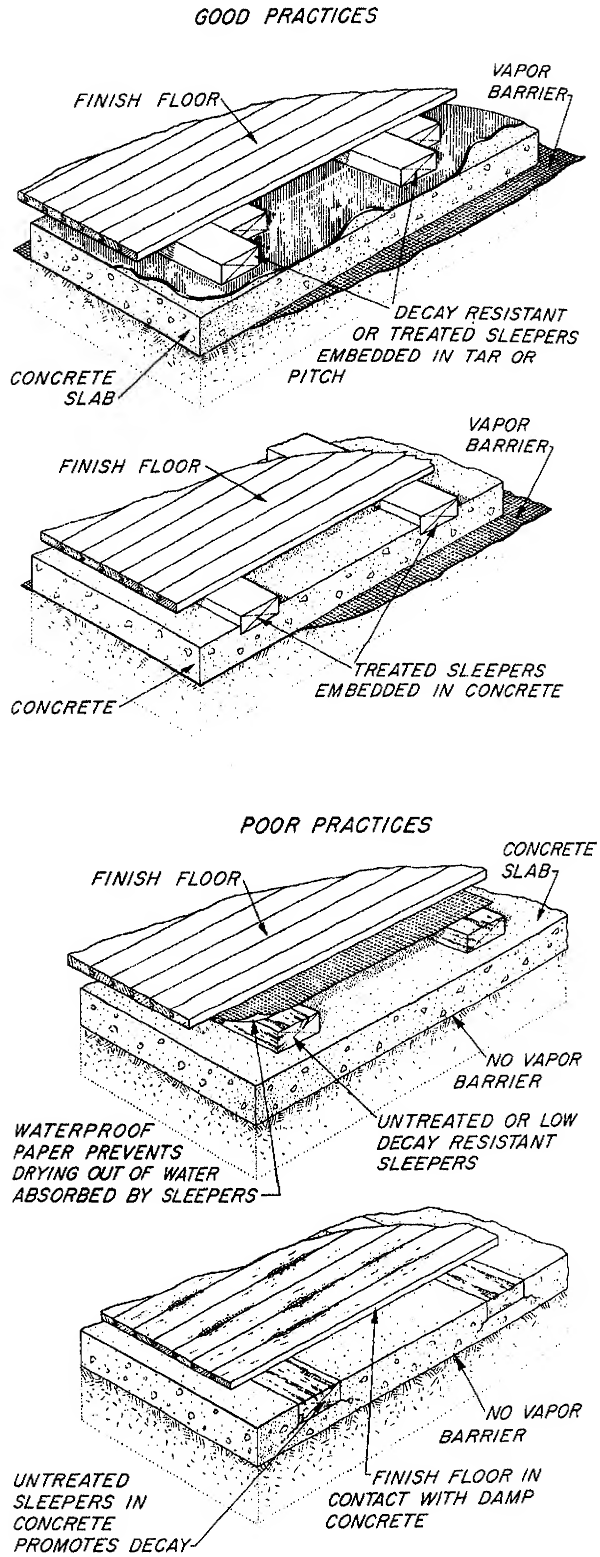

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FIGURE 16.—Good and poor practice in wood construction over concrete slabs.

in oil carriers; and (2) waterborne salts applied as water solutions.

Preservative oils are ordinarily used where resistance to leaching is desired, such as fenceposts, exposed poles, and timbers in contact with the ground. However, preservative oils applied by thorough methods may be objectionable because of odor, and because of their effect on the cleanliness, combustibility, and paintability of wood. Water-solution preservatives are used principally for treating wood that is not to be in contact with the ground or water, and where the treated wood requires painting.

Water-repellent preservatives have been used for window sash and frames for a number of years, and now are also being used on siding and exterior trim where water repellency and some protection is advantageous.

For most home and farm uses that require good preservative treatment, it is advisable that the treatment be in accordance with a recognized standard such as Federal Specification TT-W-571. Retentions recommended for preservative oils vary from 6 to 10 pounds per cubic foot and from 0.3 to 1.0 pound per cubic foot for waterborne preservatives.

The hot and cold bath is perhaps the most effective treatment that can be applied by the user even though it is not as satisfactory as pressure treating.

If the wood is to be in service above the ground, as in porches, steps supported on masonry, or railings, considerable protection from decay can be gained by soaking the lumber for about 15 minutes in the cold preservative. This should be done after the wood has been machined and drilled. A suitable preservative that will permit the wood to be painted later is a 5 percent solution of pentachlorophenol, plus water repellents, in light oil. This preservative is commonly available at lumber dealers.

How and When to Paint

The purpose of painting or staining exterior wood is to improve and maintain appearance. Painting prevents the wood from weathering and reduces cracking and warping; thereby it prevents the appearance of age and neglect that even later painting cannot remove. Paint does *not* prevent decay.

Painting characteristics of different kinds of wood are indicated in table 1 (pp. 18, 19). Edge-grained surfaces of all species of wood are superior to flat-grained surfaces in their ability to hold paint. Carefully selected edge-grained boards of redwood and western red cedar are commonly used for house siding, but flat-grained boards are generally used in most farm structures.

Because of high swelling and poor paint-holding properties, flat-grained boards are frequently better finished by staining with a red or brown pigmented penetrating stain. This kind of a finish penetrates into the wood without forming a continuous film on the surface. Therefore, it will not blister, crack, or peel, even if excessive moisture penetrates into the wood.

One way to improve the performance of stained flat-grained surfaces is to leave the wood roughsawn. Allowing the wood surface to weather several months also roughens the surface and improves it for staining. Penetrating stains are effective finishes for weathered ex-

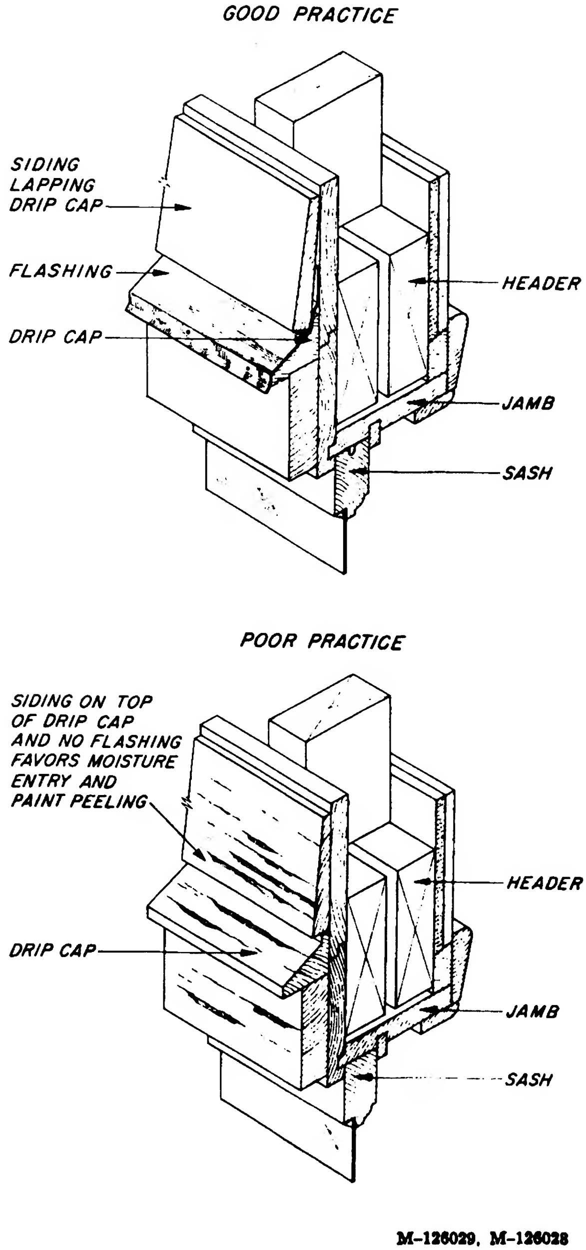

FIGURE 17.—Good and poor practice at window drip cap.

terior plywood. Surfaces that are rough textured take up more stain, and insure a more durable stain.

A single application of stain on a rough surface may be serviceable for 8 to 10 years. Pigmented penetrating stains, their composition and use, are discussed more fully in "Forest Products Laboratory Natural Finish," U.S. Forest Service Research Note FPL-046, available from the Forest Products Laboratory, North Walnut St., Madison, Wis. 53705.

In painting wood a few simple, tried-and-tested procedures will result in a coating that will give many years of satisfactory service:

Step 1—Water-repellent preservative.—Treat with water-repellent preservative before painting to protect wood against the entrance of rain or heavy dew. It is especially important that window sash and trim be so treated. This protection can be applied in two ways:

a. Use material treated by the manufacturer. On the job, retreat any cut ends by brushing on the solution.

b. Apply the entire treatment on the job by brushing. Be careful to brush the preservative well into lap and butt joints. Allow 2 warm, sunny days for adequate drying of the preservative before painting.

Step 2—Priming.—For the first or prime coat on wood, and for spot priming when repainting, use a linseed oil-base paint free of zinc-containing pigments. Follow the spreading rates recommended by the manufacturer; do not spread paint too thin. You should not be able to see the grain of the wood after priming. Priming with this oil-base paint is necessary even when the second coat is to be an exterior emulsion or latex paint.

Step 3—Finish coat.—For best results:

a. Use a high-quality paint.

b. Apply two top coats of oil-base or exterior latex (vinyl or acrylic) paint. A two-coat (primer and one top coat) job of low-quality paint may last only 3 years, but a three-coat job with good-quality paint may last 10 years.

c. To avoid intercoat peeling of paint, apply top coats within 2 weeks after the primer. Do not prime in the fall and then delay top coats until spring. Instead, treat with water-repellent preservative immediately and delay *all* painting until spring.

d. To avoid temperature blistering, do not apply oil-base paints on a cool surface that will be heated by the sun within a few hours. Rather, paint on the side the sun is on.

e. To reduce wrinkling and flatting of oil-base paint, and water marks on latex paint, do not paint late in the evenings of cool spring and fall days when heavy dews frequently form.

f. In areas where mildew is a problem, use oil-base paints that contain zinc oxide pigment, or latex paints with fungicide for top coats.

Step 4—Repainting.—A new paint is only as good as the old paint beneath, so consider these general rules:

a. Before repainting, wash old glossy and unweathered surfaces, or roughen them with steel wool to remove contaminants that may interfere with adhesion to the next coat.

b. Repaint only when the old paint has weathered so it no longer covers or protects the wood. Where wood surfaces are exposed, remove loose paint and spot prime with the zinc-free paint primer.

c. For the top coats, use good-quality latex or oil-base paint that is known to give good service.

Occasionally oil-base paint applied to wood that is very wet or green may blister, but wet wood is seldom the cause. Paint blistering is more often caused by water that works into and accumulates in the sidewalls of structures, back of the painted siding. Cold-weather condensation, rainwater, and ice dams formed on roofs by melting snow are major sources of moisture responsible for paint problems.

Preventing Entrance of Air

Infiltration of air often results in a cold and uncomfortable house even when the best kind and grade of lumber are used. Good tight construction is obtained principally by good workmanship and by use of dry lumber, good building paper properly applied when wood sheathing is used, and woods classed in table 1 as A or B in freedom from shrinkage and warping.

Poor workmanship allows the entrance of air and water because of poor fitting of miter joints at corners (fig. 10). Failure to break joints on studs and to fit siding to window sills also lets air in (fig. 11). Building paper well lapped over the wood sheathing practically seals a house against air seeping through the walls, but it cannot entirely protect the house against poor fitting at the openings.

Good building paper most efficiently excludes air when clamped between two coverings, such as sheathing and drop or bevel siding. Plywood, other wood-based panel materials, or similar types of material used in large sheets as sheathing ordinarily do not require building paper to provide a tight wall. However, it is good practice to use 12-inch-wide strips of building paper around door and window frames over sheet materials used for sheathing. Thus, after the application of the siding, air infiltration will be reduced to a minimum.

Appendix

Thermal Insulation of Wood-based Materials

An important development in modern construction practices is the increasing use of thermal insulation in houses, particularly in dwellings of intermediate and low cost. The basic objective is year-round comfort, since insulation keeps the house warmer in winter and cooler in summer. However, the saving in fuel to heat an insulated house may also justify the added cost of insulation.

Most materials used in construction offer some resistance to the transmission of heat, but wood and wood-based materials have better insulating qualities than many others. In this respect, 1 inch of Douglas-fir is equal to about 12 inches of concrete or stone in resistance to heat transmission. On the other hand, it would take about 2 inches of the wood to equal the insulating qualities of 1 inch of fiberboard.

CLASSES OF INSULATING MATERIALS

Materials that have a relatively high resistance to heat transmission are called "thermal insulators" or, more commonly, insulation. Insulating materials may be grouped into the following general classes: A, rigid insulation; B, flexible insulation; C, fill insulation; and D, reflective insulation.

Rigid insulation.—One of the most commonly used types of rigid insulation is structural insulating board. Such boards often combine insulation ability with moderate strength. In this form they are used as sheathing material and as interior finish, in laminated plank form for roof deck covering, or as an acoustic tile. These types are much better insulators on an equivalent thickness basis than solid wood, but are inferior to most flexible insulations.

Flexible insulation.—Flexible materials are ordinarily used only for insulation and are normally manufactured in blanket or batt form. In this form the insulating value is more than three times that of wood of equal thickness. Blanket and batt insulation are treated to resist fire, vermin, and decay. They are generally supplied with a vapor barrier on one side to minimize movement of water vapor through walls and ceilings.

Fill insulations.—Loose, fill-type insulations are made of materials used in bulk form and are poured or blown in place. They are used to fill stud spaces in walls and between joists in attics. Among the products most commonly used are wood fibers, granulated cork, shredded redwood bark, and ground newsprint. Fill materials have insulating values slightly less than the same material in blanket or batt form.

Reflective insulation.—Another class of insulation consists of the materials that reflect radiant heat to a high degree. Reflective insulation is effective only if the reflective surface is adjacent to a free air space of at least ¾ inch. For reflective insulation, high reflectivity is required, as provided by aluminum foil or polished metal surfaces or coatings. As an example, aluminum foil is often mounted on the back of gypsum board and thus serves both as a vapor barrier and as reflective insulation.

WHERE TO INSULATE

Insulation should be used in ceilings, walls, and floors where wide temperature differences occur on opposite sides of those surfaces. For example, in unheated attics, the insulation should be placed above the ceiling of the rooms below. In heated attics or 1½-story houses, however, the insulation should be located in the attic ceiling and down the slope of the roof to the plate, or to and through the knee wall.

In flat and pitched roofs of frame buildings, where the insulation is placed above the ceiling, a space must be left between the insulation and the roof sheathing for air circulation.

All exterior walls should be insulated including walls between heated rooms and unheated garages, porches, and similar spaces. Floors over unheated crawl spaces or porches should also be insulated.

Besides the benefit of improved living conditions in both winter and summer, added insulation will result in substantial savings in fuel. The trend has been toward greater amounts of insulation, especially in attic areas. Four inches of ceiling insulation was considered more than sufficient at one time but, with increased fuel costs, 6 and 8 inches are now used in many northern areas. Two inches or more are commonly used in the walls in these areas.

Home and Building Plans Available

The Cooperative Farm Building Plan Exchange and the Midwest Plan Service prepare complete working drawings for a large variety of homes and farm buildings adapted to all sections of the country, and all types of agriculture.

Regional committees of housing and farm building specialists in research and extension, guide, advise, and act in the execution of working drawings that are distributed through the State Extension Services at land-grant universities.

In many States, local county agricultural

agents can advise about the plans that are available. In other States, the farm building specialist, an extension agricultural engineer at the State Agricultural College, maintains lists, files, and distribution facilities for mailing working drawings. Some States make a small charge to cover the costs of printing and mailing the plans.

A short selected list of some of these home and farm building plans is given in "List No. 5, Popular Publications for the Farmer, Suburbanite, Homemaker, Consumer." This list is available free from the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250. From this list, individual sheets illustrating and summarizing the main features of each plan may be ordered free by designating an "MP" (miscellaneous publication) number. Please include your postoffice ZIP Code. These sheets give a brief description of the plans but do not generally give details required for construction. The details are given in the working drawings.

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